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Permanent Secretary Denison Scientific Association

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A study of the supposed hybrid of the Black and Shinglecaks; Earl H. Foote. 18 pp., 4 plates.
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The geological development of Ohio; F. Carney. 15 pp.
The relief features of Ohio; F. Carney. 13 pp., 1 fig.
Geographic conditions in the early history of the Ohio country; F. Carney. 20 pp.

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DENISON SCIENTIFIC ASSOCIATION

Organized April 16, 1887

REPORT OF THE PERMANENT SECRETARY FOR THE YEAR 1928–1929

The following officers served the Association during the college year 1928–1929.

B. D. GREENSHIELDS, *President*
G. D. MORGAN, *Vice-President*
R. H. HOWE, *Secretary*
R. H. HOWE, *Treasurer*
M. E. STICKNEY, *Librarian*
W. C. EBAUGH, *Permanent Secretary and Editor*

Alternating with the meetings of the Departmental Societies of Denison University, sessions of the Scientific Association were held every other Tuesday evening during the school year. Addresses were given as follows:

October

AMERICAN SCHOLARS AND THEIR SPADES IN GREEK LANDS—L. R. DEAN

OUR UNSEEN WAR—A. W. LINDSEY

November

MATHEMATICAL METHODS—F. B. WILEY

A TRIP THROUGH SPACE WITH A GIANT TELESCOPE—PAUL BIEFELD

December

VOLCANIC FEATURES OF THE WESTERN UNITED STATES—J. E. CARMAN

January

CHEMISTRY'S CONTRIBUTIONS TO COMFORT—W. C. EBAUGH

February

THE FIRST OHIOANS—H. C. SHETRONE

March

TOPS AND ROTATING BODIES—L. E. SMITH

BANKING AT THE CROSSROADS—H. L. JOME

April

WHO CAN LEARN, AND WHY—T. A. LEWIS

THE DEPARTMENT OF EDUCATION IN A LIBERAL ARTS COLLEGE—E. B. HAWES

May

FLOWERS OF VARIOUS OHIO HABITATS—ROBERT GORDON

Three numbers of the JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY were issued as follows:

Vol. XXIII, Articles 6–8, pp. 231–355, December, 1928

Hesperioidea from the Kartabo District of British Guiana; A. W. Lindsey. 5 pp., 5 figs.

A Restudy of American Orthoconic Silurian Cephalopods; Aug. F. Foerste. 85 pp., 28 plates.

The Erosional History of the Blue Ridge; Frank J. Wright. 24 pp., 10 plates.

Vol. XXIV, Articles 1–5, pp. 1–113, April, 1929

Hypoparia and Opisthoparia from the St. Clair Limestone, Arkansas; Norman L. Thomas. 26 pp., 1 plate.

Ordovician and Silurian of American Arctic and Subarctic Regions; Aug. F. Foerste. 54 pp., 2 plates.

Location Factors in the Iron and Steel Industry of Cleveland, Ohio; Charles Langdon White. 16 pp., 4 figs., 1 plate.

A Photographic Record of the Total Eclipse of the Moon; Paul Biefeld. 2 pp., 1 plate.

Basslerina, a New Holliniform Ostracode Genus, with Description of New Pennsylvanian Species from Texas and Oklahoma; Raymond C. Moore. 15 pp., 3 plates.

Articles 6–9, pp. 115–264, August, 1929

Some Proparia from the St. Clair Limestone, Arkansas; Norman L. Thomas. 14 pp., 2 plates.

Cephalopods of the Red River Formation of Southern Manitoba; Aug. F. Foerste. 107 pp., 29 plates.

A Large Fish Spine from the Pennsylvanian of North Central Texas; Raymond C. Moore. 7 pp., 1 plate.

Location Factors in the Iron and Steel Industry of the Buffalo District, New York; Charles Langdon White. 20 pp., 6 figs.

Respectfully submitted,

W. C. EBAUGH, *Permanent Secretary*

THREE STUDIES OF CEPHALOPODS

AUG. F. FOERSTE

Received November 7, 1929; published January 22, 1930

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NEW GENERA

EIFELOCERAS; genotype *Eifeloceras kayseri* Foerste.

BREYNIOCERAS; genotype, *Orthoceratites Breynii* Martin.

STENOGOMPHOCERAS; genotype, *Stenogomphoceras* chadwicki Foerste.

INTRODUCTION

The following pages include three studies of cephalopods. The first, entitled *A few European cephalopods* is of interest chiefly on account of its bearing on the use of certain generic terms. The second, on *Ordovician cephalopods from north-central states*, started with the borrowing of several species described from the

Galena phase of the Trenton in Minnesota which were regarded by Clarke as closely related to forms described by Whiteaves from the Ordovician of southern Manitoba. The third, on *American phragmoceroids and gomphoceroids* is chiefly a study of the species already described, although a number of new species are added. An attempt is made to assign these forms to their proper relationships, although it is evident that in quite a large number of cases the species have been based upon very insufficient material, very little being known of the aperture of some specimens used as types.

I. A FEW EUROPEAN CEPHALOPODS

Among the numerous cephalopods preserved in the collections of the Geological Survey of Prussia and in the Museum of Natural History, both in adjacent buildings in Berlin, many are of great interest to students of American cephalopods. For the privilege of studying these specimens the writer is under great obligations to Prof. J. F. Pompeckj, Dr. W. O. Dietrich, and Dr. Otto Schindewolf. A few of the notes which have accumulated are presented here. Some are of special interest on account of their bearing on the use of certain generic terms which are very familiar. It is becoming increasingly evident that such terms as *Lituites*, *Orthoceras*, and *Cyrtoceras* must be greatly restricted in application if they are to have any value for present methods of paleontological research. Such errors as made when two American Silurian species were identified with *Ancistroceras* and *Rhynchorthoceras* would not have been possible if the siphuncles of the American species had been compared with those from European sources. M'Coy's genus *Loxoceras* never was accepted in paleontological literature but might have value if restricted to some definite genotype, excluding unrelated forms. The term *Palaeonautilus* was given to forms very similar to *Litoceras* as defined later by Hyatt, and certainly has at least as much right to recognition as the latter genus. Several specimens of *Archiacoceras* show that although the living chamber of this genus narrowed toward the aperture, the latter never was constricted into any form even remotely suggesting *Phragmoceras*. In interpreting

European literature it is necessary to remember that the term *Phragmoceras* was used by Eichwald and others for almost any endogastric cyrtoceroid, regardless of the character of its aperture.

LITUITIDAE

The Lituitidae include the genera *Cyclolituites, Lituites, Angelinoceras, Holmiceras, Rhynchorthoceras,* and *Ancistroceras.* The stratigraphic range of this family is confined to what is known in the Baltic areas of Europe as the Orthoceras limestone. By Raymond this limestone is regarded as Chazyan. The cephalopod fauna, however, is quite distinct from anything known in the American Chazyan. In fact, the only American species which can be referred to the Lituitidae is *Cyclolituites americanus* which occurs in the Canadian of Newfoundland, while in Scandinavian countries this genus is known only from the Upper Gray division of the Orthoceras limestone. The Silurian species from Illinois and Indiana referred by Hyatt to *Ancistroceras* and *Rhynchorthoceras* are now known to have very different affinities. Both genera were fully described by Remele, but the following notes are added for the benefit of those who do not have access to the Zeitschrift der deutschen geologischen Gesellschaft, volumes 32 to 34, in which his papers appeared.

One of the most illuminating papers on *Lituites lituus,* the genotype of *Lituites,* is that by Fritz Noetling on pages 156–192 of volume 34 of the Zeitschrift just named. The accompanying illustrations show clearly why none of the American coiled forms can be referred to this genus.

ANCISTROCERAS Boll

Genotype: *Ancistroceras undulatum* Boll, Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, 11, 87 (1857).

Apical part of the conch coiled for a length of about two volutions, and then becoming straight for the remainder of its length. Along its coiled part the volutions are in contact with each other dorso-ventrally for a length of about one and a half volutions. The cross-section of the conch is circular along its straight part, and it does not deviate distinctly from circular along its curved

part, although a faint tendency toward a quadrangular cross-section may be noticed here. The surface of the shell is ornamented with transverse striae which are relatively coarse and with low and rounded crests. These striae undulate in a definite manner so as to present elevations or crests, and depressions or sinuses. Along the lower or curved part of the conch there are three conspicuous undulations, a single median, ventral or hyponomic, sinus and two ventro-lateral crests, one on each side of the sinus. Usually these three undulations can be recognized throughout the length of the conch but they become much less conspicuous along the upper half of the straight part of the conch. There is usually also a slightly angular upward flexure or crest along the median part of the dorsal side of the conch, at least along its lower part, though farther up this dorsal crest sometimes becomes obsolete. Along the upper part of some specimens a faint elevation or crest may be recognized about halfway between the dorsal crest and the two ventro-lateral crests. Usually there is a distinct, though slight, downward flexure of the transverse striae a short distance ventrad of the median line of the ventral sides, here called the lateral sinus. A fainter depression is seen in some specimens between the dorsal crest and the two crests dorsad to the lateral sinuses. The result is that 5 crests and 5 sinuses can be recognized along the upper part of some specimens of *Ancistroceras*, in the following order: one ventral or hyponomic sinus, two ventro-lateral crests, two sinuses ventrad of the median line of the lateral sides, two crests dorsad of this line, two dorso-lateral sinuses, and one dorsal crest. In addition to the transverse striae there are low and relatively numerous annulations strictly parallel to the transverse striae. The siphuncle begins with a location near the dorsal side of the conch at its apical end but shifts gradually nearer the center of the conch, though usually remaining slightly dorsad of the latter even at advanced stages of growth. The septal necks are cylindrical but short. The connecting rings also are cylindrical in some specimens, but in others they enlarge slightly within the camerae. The sharp upper margin of these rings is adnate to the exterior of the sharp lower margin of the septal neck imme-

diately above, but the lower margin of these rings invaginates distinctly into the upper part of the septal neck beneath.

At present *Ancistroceras* is known only from a single horizon, namely the upper part of the Upper Gray division of the *Orthoceras* limestone of former Scandinavian authors. The lower part of this Upper Gray division is formed by the *Illaenus centaurus* zone. This is followed in descending order by the *Asaphus platyurus* and *Megalaspis gigas* horizons, which together form the Upper Red division of the *Orthoceras* limestone of former Scandinavian authors. Both the Upper Gray and the Upper Red divisions of the *Orthoceras* limestone contain Lituitidae, but it is only in the Upper Gray division that *Ancistroceras* and *Rhynchorthoceras* occur. Since the coiled forms make their first appearance in earlier strata, it is possible to imagine that such forms as *Ancistroceras* and *Rhynchorthoceras* represent successive stages of uncoiling, the sequence, according to Hyatt, being *Cyclolituites*, *Lituites*, *Ancistroceras*, and *Rhynchorthoceras*. It should be remembered, however, that all four genera appear to occur together in the *Ancistroceras* zone, at the top of the Upper Gray division of the *Orthoceras* limestone.

According to Dr. Gustaf Troedsson, the *Ancistroceras* zone is the highest one of those horizons which he correlates with the Chazyan of America. In Scania, in southern Sweden, this zone is characterized by the presence of *Nemagraptus gracilis* (Hall), a species characteristic in America of the Normanskill member of the Upper Chazyan. The equivalent of the Upper Red division of the *Orthoceras* limestone is characterized in Scania by the presence of *Phyllograptus* cf. *typus*. That species, however, is characteristic of the Deep Kill representative of the Canadian in eastern New York. It should be remembered that nothing like the cephalopod fauna of the *Orthoceras* limestone is known from any part of the Chazyan in North America. The only representative of the family Lituitidae in American strata is *Cyclolituites americanus* Hyatt, from the Canadian of Gargamelle Cove, in Newfoundland. The evidence, as often the case when corellations are attempted between areas far apart, is conflicting. Provisionally, however, it seems safer to place the Orthoceras lime-

stone low in the Chazyan, if not actually between the Chazyan and the Canadian.

The studies on *Ancistroceras undulatum* Boll and *Ancistroceras torelli* Remele were made chiefly for the purpose of becoming acquainted with the genus, and add little to the observations made by Remele, Noetling, and Hyatt. They serve however to show that the reference of the Silurian species described by Hyatt under the name *Ancistroceras dyeri* to that genus no longer is tenable.

1. **Ancistroceras undulatum** Boll

Plate XLI, figs. 1 A, B; 3 A, B; 4 A, B, C; plate XLII, figs. 3, 4

Ancistroceras undulatum Boll. Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, 11, 87 (1857).

Conch coiled at base for a length of two volutions (plate XLI, fig. 4), becoming straight farther up. For a length of one and three-fourths of a volution these volutions are in contact with each other dorso-ventrally, except at the apical end where there is an umbilical opening about 1 mm. in length and 0.3 mm. in width. At the point where the last quarter of the second volution becomes free from the preceding volution, the diameter of this volution across the umbilical opening is 17 mm. At this point, moreover, the diameter of the conch itself is 8 mm. Twenty millimeters farther up, measured along the convex ventral side of the conch, the diameter of the conch is 15 mm. Immediately below this level 3 camerae occupy a corresponding length, namely 15 mm., when counted along the convex outline of the conch. The sutures of the septa are straight, and directly transverse to the curving central axis of the conch. The siphuncle starts close to the dorsal side of the conch at its apical end and rapidly moves toward the center, remaining slightly dorsad of the latter in earlier stages of growth. Where the dorso-ventral diameter of the conch is 1.8 mm., the siphuncle is located about one-sixth of the diameter of the conch from its dorsal side. Where the diameter of the conch is 5 mm., the center of the siphuncle is located 2 mm. from the dorsal wall, and the diameter of the siphuncle is about 0.4 mm. In another specimen (plate XLII,

fig. 4), where the dorso-ventral diameter is 9 mm., the center of the siphuncle is 4.25 from the dorsal side of the conch, and the diameter of the siphuncle is 1 mm. In this second specimen, where the diameter is 26 mm., the center of the siphuncle is 12 mm. from the dorsal wall of the conch, and the diameter of the siphuncle is 3.1 mm. Returning now to the specimen whose description was begun first, the shell of the latter is thin, possibly not exceeding one-tenth of a millimeter at the top of the specimen, where its diameter is 15 mm. Here the transverse striae rise into crests ventro-laterally, the crests being 12 mm. apart where the circumference of the conch is estimated at 47 mm. Along the median part of the ventral side these striae curve downward for a distance of 3 mm., forming U-shaped sinuses about 5 mm. wide at their bases. Dorso-laterally these striae are almost directly transverse to the curving axis of the conch, the ventro-lateral crests rising scarcely 1 mm. above their level. Along the median line of the dorsal side, the striae rise slightly in an angular manner but it is not certain that this feature is a constant one of the species. In addition to the transverse striae there are low and numerous, but relatively conspicuous transverse annulations having the same course as the striae. These are most conspicuous ventrally and ventro-laterally, but become fainter dorso-laterally and dorsally. Owing to the thinness of the shell, the annulations are well shown on casts of the interior of the conch, but the transverse striae here usually leave no traces.

Occurrence. From some unknown locality; in the Museum of the Geological Survey, Berlin, Germany.

Schönwarling specimens.—The cross-section of the conch is circular. Even along its apical part, where the volutions are in contact with each other, the cross-section is circular, and no dorsal impression can be detected. In one of the specimens from Schönwarling (plate XLI, fig. 1), about 75 mm. long, the conch becomes straight where its diameter is about 20 mm. From this point it enlarges at an angle of 28 degrees to a point where the diameter of the phragmacone is 40 mm. In this specimen the prominence of the ventro-lateral crests of the transverse striae, and the depth of the intermediate ventral sinus become conspicu-

ously less at later stages of growth, the depth of the sinus not exceeding 2 mm. at the top of the specimen. Since the ventro-lateral crests here are 30 mm. apart, the depth of the sinus appears relatively very shallow. Along the median part of the dorsal side of the conch, these transverse striae are slightly curved upward, and there are faint upward curvatures also dorso-laterally; however, only the ventro-lateral crests and the intermediate ventral sinus appear to be constant features of the species. This ventral sinus evidently locates a former position of the hyponomic sinus. Fourteen annulations occur in a length equal to the diameter of the specimen at its top. Two of the Schönwarling specimens have been sectioned vertically through the siphuncle. One specimen (plate XLII, fig. 4), 38 mm. long, has been sectioned dorso-ventrally. This enlarges from 9 mm. at its base to 28 mm. at its top, that part below a diameter of 17 mm. being distinctly curved. Throughout the length of this specimen the center of the siphuncle is slightly dorsad of the center of the conch, its distance from the dorsal side being about 0.46 of the dorso-ventral diameter. The other sectioned specimen (plate XLII, fig. 3) apparently was cut in a lateral direction. It attains a maximum diameter of 42 mm. Where this diameter is 40 mm., four and a half camerae occupy a corresponding length. At this diameter of 40 mm., that of the siphuncle is 5 mm. The septal necks here are almost 2 mm. long. The connecting rings are tubular in form. Their upper margins appear to continue the course of the similarly tubular but short septal necks; their lower margins, however, are inserted into the top of the septal necks beneath for a distance apparently equalling at least 1.5 mm. Specimens in the collections of the Geological Survey of Prussia, in Berlin, Germany.

Gischkau specimen.—Specimen 63 mm. long (plate XLI, fig. 3), slightly curved at its base, enlarging to a diameter of 32 mm. at its top. This specimen shows distinctly the lessening in prominence of the ventro-lateral crests and the diminution in depth of the intermediate ventral sinus shown by the transverse striae and annulations on proceeding from the curved part of the conch toward the top of its straight portion. Along the median part of

the dorsal side of the conch the striae are directly transverse, except along its basal concavely curved part where they bend faintly upward. There are no dorso-lateral elevations, but between the dorso-lateral and ventro-lateral outlines of the conch the transverse striae curve slightly downward. Specimen from the collection of the Geological Survey of Prussia, in Berlin, Germany.

Ober Ponves specimen.—Specimen enlarging from a diameter of 25 mm. at its base to 62 mm. at its top about 98 mm. farther up, the angle of enlargement being 24 degrees. All of this length belongs to the phragmacone, no part of the living chamber being preserved in any of the specimens at hand. Specimen in the collection of the Geological Survey, Berlin, Germany.

2. **Ancistroceras torelli** Remele

Plate XLI, figs. 2 A, B

Specimen 80 mm. long (plate XLI, figs. 2A, B), enlarging at an apical angle of 21 degrees. It is chiefly the smaller apical angle which distinguishes this species from *Ancistroceras undulatum*. The lower part of the specimen is faintly curved, the curvature being more distinct along its ventral side. The transverse annulations and striae are similar to those of the preceding species. The ventro-lateral crests and the intermediate ventral sinus are more conspicuous along the lower part of the specimen but become relatively less conspicuous toward its top. Along the dorsal side of the conch both the annulations and striae are directly transverse, but between the ventro-lateral crests and the dorso-lateral parts of the conch the striae curve slightly downward. About four and one-sixth camerae occur in a length equal to the diameter at the top of the specimen, namely 37 mm. Here the diameter of the siphuncle is estimated as one-seventh of the diameter of the conch. The septal necks are 2 mm. long, and appear to thin out at their lower margins. The top of the connecting rings appears to be adnate to the outer edge of these septal necks, and their bases to be inserted into the top of the

neck beneath, in the latter case for a length of 1.5 mm. The connecting rings are faintly inflated along the greater part of the length of the specimen, the amount of this inflation decreasing toward its top. At the base of the specimen, where its dorso-ventral diameter is 11 mm., the center of the siphuncle is about 5 mm. from the dorsal wall of the conch, but at the top, where its dorso-ventral diameter is 37 mm., the center of the siphuncle is 19 mm. from the dorsal wall, so that here it is very slightly ventrad of the center. Ordinarily its location appears to remain slightly dorsad of the center even at later stages of growth.

Occurrence.—From Baltic areas, at horizon C_1, in the *Building* limestone which directly overlies the *Echinospherites* limestone, the latter also being known as the *Illaenus centaurus* limestone, in the Museum of Natural History, Berlin, Germany.

RHYNCHORTHOCERAS Remele

Genotype: *Rhynchorthoceras beyrichi* Remele.

The genus *Rhynchorthoceras* differs distinctly from *Ancistroceras* in the slight curvature of its apical end, which may be described as cyrtoceroid; the rate of enlargement of the conch is conspicuously smaller, and the transverse striae resemble the narrow bands of some species of *Geisonoceras*, instead of being most conspicuously elevated along their middle. The structure of its siphuncle, however, is closely similar, and similarities also may be observed in the up and down curvatures of the transverse striae or bands, at least in some of the species. In both *Rhynchorthoceras beyrichi* and *Rhynchorthoceras zaddachi* there are shallow lateral sinuses, at which the transverse bands rise more conspicuously in a ventrad direction than dorsally. In *Rhynchorthoceras zaddachi* there is a faint downward curvature along the median part of the ventral side, but in neither of the two species named is there any rise of these bands along the median part of its dorsal side. The most conspicuous difference from *Ancistroceras* is the complete absence of a conspicuous downward curvature or hyponomic sinus along the ventral side of the apical part of the conch.

3. **Rhynchorthoceras beyrichi** Remele

Plate XLII, figs. 2 A, B, C

Specimen 85 mm. long, enlarging from a lateral diameter of 4 mm. at its base to 26 mm. at its top, the angle of enlargement being 15 degrees. The apical part of the conch, for a length of 25 mm. is slightly curved, the ventral outline being convex and the dorsal outline concave. Above this length of 25 mm. the conch is straight. Along the lower end of the specimen the surface of the shell is smooth, and then becomes distantly striated. These striae resemble the bands of *Geisonoceras*. Between 15 and 25 mm. above its base, 6 bands occur in a length of 10 mm. Between 35 and 45 mm., 10 bands occur in the same length. Near the top of the specimen this number varies between 8 and 9. The upward and downward curvatures of these bands are far less than in *Rhynchorthoceras zaddachi*. As a matter of fact, the course of these bands at the top of the specimen is virtually straight for a width of 20 mm. across its ventral side. Then they curve distinctly downward in a dorsad direction for a width of 10 mm., rise slightly for a width of 6 mm., and cross the dorsal side of the conch in a straight direction, the entire circumference of the conch here being estimated at 83 mm. From these measurements it is evident that the lowest parts of the lateral sinuses are 40 mm. apart across the ventral side of the conch, and that from these sinuses the bands rise more rapidly in a ventrad than in a dorsad direction. The sutures of the septa are directly transverse. At the top of the specimen the septum has a concavity of 8 mm. The center of the siphuncle is 11.5 mm. from the ventral wall of the conch, where the diameter of the conch is 26 mm. The diameter of the siphuncle here is 4.5 mm. Its septal neck is 2 mm. long. Both the neck and the connecting ring are cylindrical in form. The upper margin of the ring slightly overlaps the exterior of the sharp edge at the base of the neck above, and its lower end invaginates for a length of 1.5 mm. into the top of the neck beneath. Four camerae occur in a length equal to the diameter of the conch at the top of the specimen. The shell is very thin.

Occurrence.—Osselsk. In the collections of the Geological Survey, Berlin, Germany.

4. **Rhynchorthoceras zaddachi** Remele

Plate XLII, figs. 1, 5

Specimen 143 mm. long, 65 mm. of this length being occupied by the living chamber. The phragmacone (plate XLII, fig. 5) enlarges at an angle of 13 degrees, and the living chamber at 10 degrees, the significant diameters being 12 mm. at the base of the specimen, 29 mm. at the base of the living chamber, 75 mm. farther up, and 38 mm. at a point 50 mm. above the latter. Along the upper 10 mm. of the length of the specimen, the cast of the interior of the living chamber is contracted slightly, but the exterior of the shell presents no evidence of this contraction. Evidently this contraction corresponds to a thickening of the interior of the shell, a feature not uncommon along the upper part of living chambers in orthoceroids. The ventral vertical outline of the conch is slightly curved in a convex direction, the amount of this convexity not exceeding 3 mm. in its entire length. Its dorsal outline, on the contrary, is practically straight. The more apicad part of the conch, below the diameter of 12 mm., probably was more distinctly curved, as in other specimens of *Rhynchorthoceras*, but this part is not preserved. The surface of the shell is distinctly striated in a transverse direction, the striae resembling the narrow bands of some species of *Geisonoceras*. Along the phragmacone the number of these bands in a length equal to the diameter of the conch equals 19 or 20, increasing to 24 along the upper part of the living chamber. The course of these transverse bands presents similarities to that of the transverse striae of *Ancistroceras*. For instance, along the ventrolateral sides of the conch these bands curve distinctly upward, forming crests whose highest points are 21.5 mm. apart where the circumference of the conch is estimated at 81.5 mm. However, the intermediate part of these bands, which in *Ancistroceras* is marked by a ventral sinus which is very conspicuous at early stages of growth and readily perceptible though shallow at later stages, in the specimen of *Rhynchorthoceras* here under descrip-

tion curves only faintly downward. Dorsad of the ventro-lateral crests the transverse bands curve downward rather conspicuously, forming lateral sinuses whose lowest points are 37 mm. distant from each other where the circumference of the conch is 81.5 mm. Dorsad of these sinuses, the transverse bands rise again, but at a smaller rate than their rise in a ventrad direction, and then they become horizontal for a distance of 23 mm., while crossing the dorsal side of the conch. The septum at the base of the living chamber has a concavity of 7 mm. The center of the siphuncle here is located 11 mm. from the dorsal wall of the conch, the diameter of the conch being 29 mm. The siphuncle is 3.5 mm. in diameter.

Occurrence.—Limekiln near Lebbin, Germany; north of Stettin, in the bight of Pommerania. In the collection of the Geological Survey, Berlin, Germany.

Kunzendorf specimen.—Specimen (plate XLII, fig. 1) about 90 mm. long, enlarging at an angle of 13.5 mm. from a diameter of 29 mm. at its base to 46.5 mm. at a point 77 mm. farther up. Each of the 2 camerae at its base is 7 mm. long, 66 mm. belonging to the living chamber, the top of the latter probably not being preserved. Along the upper part of this chamber the two ventro-lateral crests formed by the transverse bands are 34 mm. apart, the circumference here being 149 mm. The lowest parts of the lateral sinuses are 70 mm. apart. The siphuncle is virtually central in location, its center being 13.5 mm. from the ventral wall where the diameter of the conch is 29 mm. Found at Kunzendorf, in Silesia, Germany, 30 miles northwest of Breslau. Preserved in the collections of the Geological Survey, Berlin, Germany.

ORTHOCERAS Breynius

As already well known, Breynius applied the term *Orthoceratites* to a cephalopod in 1732, before the concept of a specific name as distinguished from a generic name had been introduced by Linnaeus. Hence no specific name accompanies his term *Orthoceratites*.

In 1809, Martin described and figured two species in his Petri-

ficata Derbiensis, one of these under the name *Conchyliolithus Nautilites Orthoceratites (Gesneri)*, as cited by Foord, and the other as *Conchyliolithus Nautilites Orthoceratites Breynii*. Both of these are Carboniferous species very different in structure from the form to which Breynius applied the term *Orthoceratites*. In the present paper Martin's second species is made the genotype of *Breynioceras*.

In 1813, Schlotheim used the term *Orthoceratites* for two species in his contribution to Leonhard's Taschenbuch für Mineralogie, one under the name *Orthoceratites Oelandicus*, and the other under *Orthoceratites cochleatum*. The first of these is a species of *Orthoceras* as this term is used at present, and the second is usually referred to *Actinoceras*, and probably belongs to the more recently proposed genus *Armenoceras*.

In 1814, Sowerby used the term *Orthocera striata* for a species described and figured in his Mineral Conchology, vol. 1, pl. 58. This species later was referred by Foord to *Actinoceras*, and in the present paper it is included in *Breynioceras*. *Orthocera undulata* figured on pl. 59 of the same publication later was named *Orthoceras (Loxoceras) Sowerbyi* by M'Coy and here is also included in *Breynioceras*.

In 1815 Fleming described five species in the Annals of Philosophy under the names *Orthocera laevis*, *O. pyramidalis*, *O. cylindracea*, *O. sulcata*, and *O. undata*.

In 1816, Sowerby figured *Orthocera annulata* on pl. 123 of vol. 2 of his Mineral Conchology.

In 1820 Schlotheim described *Orthoceratites regularis* in his work on Die Petrefactenkunde. This is a different species from that figured by Breynius.

It has not yet been ascertained when for the first time the spelling *Orthoceras* was substituted for *Orthoceratites* and *Orthocera*. The preceding notes are sufficient however to indicate that the species name *regularis* used by Schlotheim is preceded by a considerable number of specific names used by other authors. A considerable number among the latter belong to species whose affinities are not at all similar to those indicated by the figures published by Breynius, nor to those included in *Orthoceras* in its

restricted sense, as proposed by Hyatt. Evidently Schlotheim's *Orthoceratites regularis* can not be used as a genotype.

LOXOCERAS McCoy

Genotype: *Loxoceras distans* McCoy, Syn. Carb. Foss. Ireland, 6, fig. 3 (1844); *Orthoceras perellipticum* Foord, Catalogue of Fossil Cephalopoda, pt. 1, 104 (1888).

The genus *Loxoceras* was defined by McCoy as consisting of orthoceracones "in which the section is oval, the septa waved and placed obliquely with respect to the axis of the shell, and the siphuncle is excentric." This description is accompanied by a small figure in which the sinuosity of the sutures of the septa agrees with that of *Loxoceras distans* McCoy, though the septa are drawn as though placed closer together. Nothing is known of the structure of its siphuncle, but its septa are so far apart and the diameter of the septal necks is so small that it is very unlikely that the segments of the siphuncle of this species were nummuloidal or even moniliform in outline. It is much more likely that if these segments were not approximately cylindrical they, at least, enlarged only moderately within the camerae.

In the Kildare specimen, here described, the obliquity and sinuosity of the sutures of the septa is similar to that of *Loxoceras distans;* the structure of the siphuncle, on the contrary, is distinctly nummuloidal, and so suggests a different generic relationship.

5. Loxoceras kildarense Sp. nov.

Plate XLIII, figs. 1 A, B

Specimen 135 mm. long, enlarging evenly along the phragmacone and the lower half of the living chamber, but contracting slightly along the upper half of this chamber in a subfusiform manner. The dorso-ventral diameter enlarges from 38 mm. near the base of the specimen to 55 mm. at a point 65 mm. farther up, this point being located at the top of the dorsal side of the phragmacone. At this level the ventral side of the conch begins to contract, while the dorsal side does not begin to contract until 23 mm. farther up. The line along which this contraction begins

is parallel to the sutures of the septa beneath, and therefore rises strongly from the ventral toward the dorsal side of the conch. The lateral diameters of the conch can not be determined with accuracy at present, since the specimen has been sectioned vertically in a dorso-ventral direction, and it is not known how much of the width of the conch was removed during sectioning, but apparently the lateral diameter was slightly greater than the dorso-ventral one. Eight camerae occur in a length equal to the dorso-ventral diameter at the top of the series counted. The maturity of the conch is indicated both by the contraction of the upper half of the living chamber, and by the shortening of the uppermost camera. The sutures of the septa rise at an angle of 10 degrees above the horizontal from the ventral toward the ventro-lateral parts of the conch, and then this rise increases to 20 degrees as far as the dorsal outline. The center of the siphuncle is located 9 mm. from the ventral wall of the conch where the dorso-ventral diameter of the conch is 38 mm., this distance increasing to 10.5 mm. where the dorso-ventral diameter is 49 mm. The dorsal outline of the connecting ring is preserved on the right half of the lowest camera, and the ventral outline of the immediately overlying connecting ring is preserved on the left half of the specimen in its present sectioned condition. From this it is estimated that the diameter of the second segment of the siphuncle was 12.5 mm., the height of this segment being 6 mm., and the passage of the siphuncle through the septa immediately above and below being 4.5 mm. in diameter. The septal necks are scarcely 1 mm. in length, and strongly curved outward at their margins. The thickness of the shell varies from 0.75 mm. along the lower part of the specimen to 3 mm. at mid-height of the living chamber, diminishing to about 0.75 mm. near the aperture. Judging from the obliquity of the line along which the upper part of the living chamber contracts, the margin of the aperture was approximately parallel to the sutures of the septa beneath. In the absence of the margin of the aperture and also in the absence of all traces of striae on the surface of the shell, it is impossible to determine whether a hyponomic sinus was present. Possibly the ventral side of the aperture served as such

a sinus. Apparently the location of the siphuncle was endogastric, but this also remains uncertain.

Occurrence.—Kildare, 30 miles southwest of Dublin, Ireland; Carboniferous limestone. Museum of Natural History, Berlin, Germany.

Remarks.—The nearest form resembling the specimen here described is that described by Foord under the name *Orthoceras subclavatum*, in his Monograph of the Carboniferous Cephalopoda of Ireland, in 1903. However, on plate 4 accompanying this description the siphuncle is figured as having much narrower segments, not at all nummuloidal in form, and not even wider than long.

EIFELOCERAS Gen. nov.

Genotype: *Eifeloceras kayseri* Sp. nov.

Conch apparently slightly curved lengthwise, but a part of this curvature evidently is due to a slight ventrad displacement of the lower end of the specimen along a transverse fracture. Distinctly depressed dorso-ventrally. The sutures of the septa curve downward laterally and rise both dorsally and ventrally, forming broad saddles, but the ventral saddles are distinctly more elevated than the dorsal ones. Siphuncle distinctly nearer the dorsal side of the conch, its location being endogastric. Its septal necks are short and their lower margins are directed diagonally downward and outward. The segments of the siphuncle evidently enlarge within the camerae, but the amount of this enlargement can not be determined. The curvature of the septa is readily determined from the curvature of their sutures, since these sutures do not curve in a lateral direction but only dorso-ventrally.

6. **Eifeloceras kayseri** Sp. nov.

Plate XLIV, figs. 2 A, B, C, D

Specimen 62 mm. long, the living chamber occupying 22 mm. of this length when measured along the middle of its lateral side. The dorso-ventral diameter of the phragmacone enlarges from 8.5 mm. at its base to 14.5 mm. at its top, 38 mm. farther up.

The lateral diameter at the top of this phragmacone is 18 mm. The living chamber enlarges laterally at an angle of 15 degrees. The phragmacone has been sectioned vertically in a dorso-ventral direction so that its original rate of enlargement in a lateral direction can not be determined definitely but it is estimated as also equalling about 15 degrees. The conch is distinctly depressed dorso-ventrally. Its dorsal side is slightly more flattened than its ventral one. Eight camerae occur within a length equal to the lateral diameter of the conch at the top of the series counted. The sutures of the septa curve downward laterally. At the top of the phragmacone this downward curvature equals 2 mm. and its maximum depth is slightly dorsad of the middle of its lateral sides. The ventral saddles at this point rise about 1 mm. higher than the dorsal ones. The septa curve dorso-ventrally but not in a lateral direction. Where the dorso-ventral diameter of the conch is 14.5 mm., the center of the siphuncle is 3 mm. from the dorsal wall of the conch. The diameter of the septal necks here is 1.5 mm. and their length is 0.5 mm. On the ventral side of the siphuncle these necks are shorter and curve more distinctly outward. On its dorsal side they are directed diagonally downward in a dorsad direction. The connecting rings are not preserved but it is estimated from the curvature of these necks that the rings were about 2.5 mm. in diameter and about 1.3 mm. in height, where the height of the camerae is 2 mm. There is no trace of any calcareous deposit within the area once occupied by the siphuncle. The specimen is a cast of the interior of the conch and no trace of surface ornamentation remains.

Occurrence.—From the Eifel area of Germany; in the Middle Devonian. In the Museum of Natural History, Berlin, Germany. Collected by Dr. Kayser in 1871.

BREYNIOCERAS Gen. nov.

Genotype: *Orthoceratites Breynii* Martin, Petrificata Derbiensis, pl. 39, fig. 4 (1809); figure copied by Foerste in Jour. Sci. Lab. Denison Univ., 21, pl. 9, fig. 2 (1925).

Conch straight, depressed dorso-ventrally. Sutures of septa curving distinctly downward ventrally. Siphuncle ventrad of

the center of the conch, much smaller compared with the diameter of the conch than in typical *Actinoceras*. Interior of siphuncle occupied by vertical lamellae radiating from the walls of the siphuncle toward its center but not reaching the latter, agreeing in this respect with typical Actinosiphonata. The description of the genotype, as given by Sedgwick in his "Synopsis of the Classification of the British Palaeozoic Rocks, p. 567 (1854), is republished on page 26 of the number of the Journ. Sci. Lab. Denison University cited above, and a part of this description is given on page 226 of volume 20 (1924) of this journal. According to Foord the siphuncle is located midway between the center of the conch and its ventral wall. According to the description given by Sedgwick the segments of the siphuncle are about twice as wide as long, the size of the siphuncle being small compared with the diameter of the conch. Surface (indistinct) apparently marked with fine, obtuse, transverse striae. Its horizon is the Carboniferous limestone, and the specimens in the British Museum of Natural History are from Bolland, Yorkshire.

Two other species present closely similar characteristics. One of these is the species described by Sowerby in his Mineralogy and Conchology (vol. 1, p. 129, pl. 58, 1814) as *Orthocera striata* and later referred by Foord to *Actinoceras*, and the other includes the two specimens described by Sowerby in the same publication under the names *Orthocera undulata* and *Orthocera Breynii?* and for which M'Coy, in 1855, proposed the name *Orthoceras* (*Loxoceras*) *Sowerbyi*, later also referred to *Actinoceras* by Foord.

PALAEONAUTILUS Remele

Genotype: *Palaeonautilus hospes* Remele. Untersuchungen über die versteinerungsführenden Diluvialgeschiebe des norddeutschen Flachlands mit besonderer Berücksichtigung der Mark Brandenburg. I Stück, 3 Lieferung, I Theil, 1890, p. 37. Reprint from the Festschrift für die fünfzigjahrige Jubelfeier der Forstakademie Eberswalde, 1880.

Conch closely similar to *Trocholites*, but enlarging more rapidly in a lateral direction and strongly unfolded so as to expose only

the dorsal half of the inner volutions of the conch. The general aspect of the conch is less disk-like than in typical *Trocholites*, and distinctly more rotund. The aperture is similar to that of *Trocholites*. The ventral sinus has a depth of at least 5 mm. and the ventro-lateral crests of the aperture flare strongly outward. The shell is thick and closely striated transversely, the striae curving strongly downward ventrally showing that earlier states of the hyponomic sinus were V-shaped, with narrowly rounded angles. The transverse striae tend to be grouped so as to produce low ribs of which from 5 to 6 occur in a length of 10 mm. along the upper half of the living chamber.

7. **Palaeonautilus hospes** Remele

Plate XLIII, figs. 2 A, B; plate XLIV, figs. 4, 5

Palaeonautilus hospes Remele, Zeitschr. d. deutsch. geol. Gesellschaft, 33, (13), p. 2, fig. 1 (1881).

Trocholites hospes Schröder, Ceph. d. Untersilur., Pal. Abh., Dames and Kayser 5, pt. 4, (5), pl. 1, figs. 8, 9 (1891).

Specimen (plate XLIV, fig. 4) with a maximum diameter across the umbilical opening of 55 mm. The lateral diameter of the last volution enlarges from 20 mm. to 33 mm. within a length of 90 mm., this length being measured along the lateral outline of the conch, and terminating immediately behind the flaring aperture. According to these measurements the last volution of the conch enlarges at an angle of 8.5 degrees laterally. The living chamber occupies two-thirds of the length of the last volution. A trace of the shell, almost 1 mm. thick, remains along the hyponomic sinus of the aperture. Its surface was ornamented by closely crowded transverse striae and relatively numerous transverse ribs. Undulations corresponding to the ribs cross the cast of the interior of the chamber, numbering about 15 in a length equal to the lateral diameter of the conch, when counted along the ventral outline of the latter. These ribs curve downward about 8 or 9 mm., and tend to form a V-shaped sinus, rounded at its base. At the aperture, the conch flares outward, apparently in an irregular manner. The amount of the flaring in a lateral

direction is unknown but appears to have been small. Apparently the amount of flaring increased in a ventral direction and was greatest at the ventro-lateral crests bordering on the hyponomic sinus. These crests curve outward 8 or 9 mm. beyond the regular curvature of the ventral side of the living chamber. Their most elevated points are 17 mm. apart, and the intermediate sinus is 7 mm. in depth. Immediately beneath this sinus the median outline of the ventral side curves outward 4 or 5 mm. in a length of 10 or 12 mm. At the top of the phragmacone 4 camerae occur in a length equal to the lateral diameter of the conch. The sutures of the septa curve moderately downward ventrally. Evidently the entire shell was relatively thick, considering its small size, its thickness along the sides of the last volution varying from 0.7 mm. at its smaller end to nearly 1 mm. toward the aperture.

Occurrence.—Herzsprung, Uckermark, Germany. From the upper gray *Orthoceras* limestone which includes an upper *Ancistroceras* horizon and a lower *Illaenus centaurus* horizon. The label mentions the *Chiron* limestone, probably as a synonym for the gray *Lituites* limestone, the latter being identical with the upper gray *Orthoceras* limestone of earlier Scandinavian authors, and *Illaenus chiron* at present being regarded as identical with *Illaenus centaurus*. Museum of Geological Survey of Prussia, Berlin. Herzsprung is 30 miles east of Wittenberg.

Lieseneff specimen.—The maximum diameter of this specimen (plate XLIII, figs. 2 A, B; pl. XLIV, fig. 5) across its umbilical area is 52 mm. Apparently the specimen consisted of a little more than 4 volutions. The lateral diameter at the larger end of the specimen is 32 mm.; one volution back from this end it is 23 mm.; two volutions back it is 8 mm.; three volutions back it is 3.5 mm. There is room for a fourth volution, but only the last three-fifths of this initial volution is preserved, the apical end being replaced by calcite which also fills the umbilical aperture. It is estimated that this umbilical aperture was about 2 mm. long and 1.3 mm. wide. The cross-section of the conch is reniform, its dorsal side being strongly impressed at contact with the preceding volution. At the base of the living chamber, where the lateral

diameter is 23 mm., the impressed zone along its dorsal side is 12 mm. wide and 3.5 mm. deep. The dorso-ventral diameter of the conch here is 11 mm. The siphuncle is 2 mm. in diameter, and its center is 2 mm. from the dorsal wall of the conch. The concavity of the septum is 3.5 mm. in a dorso-ventral direction. In a lateral direction it is more deeply concave but less strongly curved. The segments of the siphuncle are tubular, and do not expand within the camerae. The larger end of the specimen curves distinctly outward for a short distance along the median part of its ventral side. This end evidently was broken across just posterior to the hyponomic sinus indenting the ventral side of its aperture. There are traces of very fine transverse striae on the surface of the remnant of the shell along the upper part of the living chamber, but no transverse ribs. The thickness of the shell is almost 1 mm. From Lieseneff near Schivelbein, 50 miles northwest of Stettin, in Pommerania, Germany. Museum of Geological Survey of Prussia, Berlin.

CYRTOCERAS Goldfuss

Genotype: *Cyrtoceras depressum* Bronn, Lethaea Geognostica, 2nd ed., 1, 101, pl. 1, fig. 5 (1837).

Conch relatively large, considering that it is a cyrtoceroid. Ventral vertical outline convex, dorsal outline concave. Depressed dorso-ventrally, especially at later stages of growth, with a tendency toward triangularity of its cross-section, chiefly owing to flattening of its dorsal side, with a faint elevation of the median part of its ventral side. Along the upper part of the phragmacone the sutures of the septa rise strongly in a ventrad direction, the sutures curving downward slightly along the lateral sides of the conch, the lowest part of this curvature being located dorso-laterally. The siphuncle is located near the ventral wall of the conch, but not in contact with the latter. The dorso-ventral vertical section through the siphuncle is either slightly concave or nearly straight along that side of the siphuncle facing the interior of the conch; along its ventral side it is nearly straight, more or less concave, or scalariform, with the lower part of each connecting ring nearer the ventral wall of the conch, and its

basal part adnate to the upper surface of the septum beneath. The interior of the siphuncle is occupied by vertical lamellae which extend from the walls partway toward the center, the central part usually being occupied by crystalline calcite. The surface of the shell is occupied by transverse striae which curve downward along the median part of the ventral side of the conch. The living chamber is relatively short, and along its aperture the downward curvature of the transverse striae developes into a distinct, though relatively shallow hyponomic sinus.

Only two species of *Cyrtoceras* are known to the writer. These are *Cyrtoceras depressum* and *Cyrtoceras lineatum*. Both of these names were proposed by Goldfuss at the time of his description of the genus *Cyrtoceras*, but they were not described or figured by him, this task falling to later authors. Both species are from the *Stringocephalus* horizon in the upper part of the Middle Devonian of Germany.

The nearest approach to *Cyrtoceras* among other described species is presented by *Conostichoceras palinurus* (Barrande) and *Turnoceras turnus* (Barrande), both from the Middle Devonian of Hlubocep, Bohemia. Both have depressed subtriangular cross-sections, more or less flattened dorsally, but in neither species do the sutures of the septa rise strongly in a ventrad direction along the upper part of the phragmacone, and in neither is the aperture known to have a distinct hyponomic sinus. In *Blakeoceras empiricum*, also from Hlubocep, the cross-section is compressed, rather than depressed. In *Karoceras typicum* Foerste, from Novaya Zemblya, possibly from the Devonian, the conch is still more compressed. All of these species agree in having converging vertical lamellae projecting from the inner walls of the siphuncle toward its interior, and in none of these are the segments of the siphuncle nummuloidal. *Karoceras* has a scalariform structure along the ventral vertical outline of the siphuncle. *Blakeoceras* may have a similar structure. The ventral vertical outlines of the siphuncles of *Conostichoceras* and *Turnoceras* are unknown, the vertical sections of the siphuncle published by Barrande being in a lateral direction, but there is a possibility that all of these genera may be found to belong to the

same general group of cephalopods. At least, none of them are known to have nummuloidal segments of the siphuncle as in typical actinoceroids.

8. **Cyrtoceras depressum** Bronn

Plate XLIV, figs. 1, 3

Cyrtocera depressa Goldfuss, in von Dechen's Handb. der Geognosie von H. T. De la Beche, 536 (1832). Neither figured nor described.

Cyrtocera depressa Bronn, Lethaea Geognostica, 2nd ed., 1, 101, pl. 1, fig. 5 (1837). This figure was copied in Jour. Sci. Lab. Denison Univ., 21, pl. 18, fig. 2 (1925).

Cyrthoceratites depressus d'Archiac and de Verneuil, Trans. Geol. Soc. London, 2nd ser. 6, pt. 2, 350, pl. 29, figs. 1, 1a (1842). Figures copied in Jour. Sci. Lab. Denison Univ., 21, pl. 35, figs. 1A, B (1926).

Cyrtoceras depressum Foord, Cat. Foss. Cephalopoda in British Museum, pt. 1, 263, figs. 46 a, b (1888). Figures copied in Jour. Sci. Lab. Denison Univ., 21, pl. 46, figs. 2 A, B.

Specimen consisting of the upper part of a phragmacone (plate XLIV, fig. 1), evidently strongly convex in a lengthwise direction, since the 7 camerae exposed along its ventral margin there occupy a length of 100 mm., while along its dorsal outline they occupy a length of only 28 mm. Above this level, parts of two additional camerae occur. Within this length the radius of curvature of the convex ventral outline varies between 150 mm. and 170 mm. At the base of the specimen the lateral diameter is 110 mm. and the dorso-ventral one is 95 mm. The cross-section of the conch is subtriangular. This appearance is produced by several causes: the maximum lateral diameter is located 35 mm. from the dorsal outline of the conch, while 60 mm. from the ventral one; the dorsal outline of the cross-section is flattened distinctly for a width of 60 mm.; and the median part of the ventral side is slightly more rapidly rounded than the ventro-lateral sides of the specimen. The number of camerae in a length equal to the dorso-ventral diameter at the top of the series counted equals 8, the counting being done along the ventral

outline of the specimen. The sutures of the septa are directly transverse dorsally, curve slightly downward dorso-laterally, and then rise increasingly in a ventrad direction on approaching the top of the phragmacone. On approaching the median part of the ventral side of the conch the rate of rise of the sutures of the septa is lessened, so that there appears to be a faint reversal of curvature here. At the base of the specimen, the center of the siphuncle is located 15 mm. from the ventral wall of the conch, the dorso-ventral diameter of the latter here being 95 mm. The diameter of the siphuncle at this point is 9 mm.; five camerae farther up it is 11 mm. Along that side of the siphuncle which faces the interior of the conch, the septal necks curve downward about 4 mm., the general vertical outline of the segment of the siphuncle included within each camera here being concave. Along the ventral side of the siphuncle, the septal necks curve downward for a distance of 6 mm., the general vertical outline of each segment here being approximately straight. The interior of the siphuncle is occupied by vertical lamellae which project inward from the walls of the siphuncle. The central part of the siphuncle is occupied only by matrix. The number of these vertical lamellae equals at least 20 and may exceed 25. The septa thicken on approaching the siphuncle from the dorsal side of the conch and continue thick from the siphuncle as far as the ventral wall of the conch.

Occurrence.—Pelm railroad station, a mile northeast of Gerolstein in the Eifel area of Germany. Middle Devonian, presumably from the *Stringocephalus* horizon. In the collections of the Geological Survey of Prussia, Berlin, Germany.

Another Eifel specimen.—Specimen 83 mm. long (plate XLIV, fig. 3), its convex ventral outline with a radius of curvature of 85 mm., enlarging dorso-ventrally from a diameter of 55 mm. at its base to 75 mm. at its top when measured parallel to the sutures of the septa. Laterally, the corresponding diameters are approximately 57 mm. and 82 mm. Seven camerae occupy a length equal to the dorso-ventral diameter at the top of the series counted, if counted along the ventral outline. The sutures of the septa slope downward slightly in a ventrad direction at the base of the specimen, but rise strongly in this direction toward its

top. They curve downward dorso-laterally, and are directly transverse along the flattened part of the dorsal side. At the base of the specimen its siphuncle is 5 mm. in diameter, and the center of the latter is 7 mm. from the ventral wall of the conch. The septal necks vary from 1.5 to 2 mm. in length along the side of the siphuncle facing the interior of the conch, and from 2.5 to 3 mm. in length ventrally. Along that side facing the interior of the conch, the vertical outline is gently concave. Along the ventral side, the vertical outline of each segment also tends to be concave, but toward the base of each segment this outline approaches nearer the ventral wall of the conch, the basal part of the segment being adnate to the upper surface of the septum beneath for a distance varying between 1 and 2 mm. The interior of the siphuncle is occupied by about 20 vertical lamellae extending from the walls of the siphuncle toward its interior, the center for a diameter of 1 or 2 mm. being occupied by crystalline calcite.

Locality and horizon.—From the Eifel area of western Germany; Middle Devonian, presumably from the *Stringocephalus* horizon. Museum of Natural History, Berlin, Germany.

Bredelar specimen.—Conch strongly curved lengthwise, enlarging much more rapidly laterally than dorso-ventrally. Cross-section subtriangular, the dorsal side broad and flat, the ventral side strongly convex but with a tendency toward angulation along its median part. Living chamber relatively short. Margin of aperture almost directly transverse to the curving central axis of the conch. The hyponomic sinus is distinct but shallow. It becomes well defined laterally only at mature stages of growth. The transverse striae crossing the lower part of the living chamber slope downward more gradually, with a much more moderate angulation along the median part of the ventral side of the shell. Found at Bredelar, 30 miles northwest of Kassel, in Waldeck, Germany. From the *Stringocephalus* zone of the Middle Devonian. Geological Survey of Prussia, Berlin, Germany.

9. **Cyrtoceras lineatum** d'Archiac and de Verneuil

Plate XLVIII, fig. 5

Cyrtocera lineata Goldfuss, in von Dechen's Handb. der Geognosie von H. T. De la Beche, 536 (1832).

Cyrthoceratites lineatus d'Archiac and de Verneuil, Trans. Geol. Soc. London, 2nd Ser., 6, pt 2, 351, pl. 30, figs. 2, 2a (1842).

Cyrtoceras depressum Foerste, Jour. Sci. Lab., Denison Univ. 21 pl. 46, figs. 1 A, B.

Specimen 120 mm. long, slightly curved, the radius of curvature along the convex ventral outline being 175 mm., while the concavity of the dorsal outline in a length of 83 mm. scarcely equals 2 mm. The specimen enlarges dorso-ventrally from a diameter of 54 mm. at its base to 80 mm. at its top; the corresponding lateral diameters are 58 mm. and 99 mm. At the smaller end of the specimen its cross-section is almost circular, its dorso-ventral depression being small, but at later stages of growth the depression becomes more conspicuous, and the cross-section slightly triangular. This triangularity is produced partly by the flattening of the dorsal side of the conch and partly by the increased development of the groove along the median part of this side. This groove is scarcely perceptible at the lower end of the specimen, but it widens to 20 mm. at its top, and deepens to fully 1 mm. Nine camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series of camerae counted, provided this counting is done along the ventral outline of the conch. At the lower end of the specimen the sutures of the septa slope downward in a ventrad direction at an angle of 18 degrees with a directly transverse plane. Seven camerae farther up the sutures are directly transverse. At the top of the specimen the sutures of the septa rise at an angle of 13 degrees in a ventrad direction. Along the upper part of the specimen the sutures curve slightly downward laterally, their maximum downward curvatuve being dorso-lateral. The concavity of the septum at the top of the specimen is 9 mm., with the maximum concavity dorsad of the center of the conch. In a lateral direction its concavity is less. The distance from the center of the siphuncle to the ventral wall of the conch is 8 mm. at the base of the specimen and 13 mm. at its top. The passage of the siphuncle through the septa at these two places equals 4.5 mm. and 8 mm. respectively. The lower part of the specimen has been sectioned vertically in a dorso-ventral direction for a length of 4.5

camerae. The septal necks here are about 2 mm. in length. Along the ventral side of the siphuncle the vertical outline of these necks is parallel to the vertical axis of the siphuncle, but along the dorsal side these necks slope downward and inward at an angle of 25 degrees with the vertical axis. Aside from the septal necks, the remainder of the dorsal side of the siphuncle is straight and parallel to the axis named. Ventrally, however, the vertical outline of connecting rings of the siphuncle slopes downward and outward at an angle of 15 degrees with the vertical axis until near the base of the camera, where it curves strongly dorsad, and becomes adnate to the top of the septum beneath for a distance of 1 mm. The interior of the siphuncle is occupied partially by vertical lamellae which extend inward from the walls of the siphuncle for a distance of 1 mm. or slightly more, leaving a central space 2 mm. in diameter, occupied by crystalline calcite. The cast of the interior of the conch is covered by low vertical ribs, inconspicuous except when illuminated transversely. About 9 or 10 of these ribs occur in a width of 20 mm. at mid-length of the specimen. Along the middle of the ventral side of this cast there are obscure traces of the former locations of the very shallow hyponomic sinus indenting the margin of the aperture of the conch at earlier stages of growth. The shell appears to have been thick dorso-laterally and laterally, thinning ventrally and along the median part of the dorsal side. The surface of the shell is striated transversely, the striae being very fine and relatively inconspicuous. Along the dorsal and lateral sides of the conch they are almost directly transverse; ventrally the shell is not preserved.

Occurrence.—Wachtberg, near Sötenich, in the Eifel of Germany, 15 miles southwest of Euskirchen. In the *Stringocephalus* zone of the Middle Devonian. Geological Survey of Prussia, Berlin, Germany.

In the collections of the Geological Survey in Berlin there is a specimen of *Cyrtoceras lineatum* which preserves the living chamber. This is relatively short. The margin of the aperture is almost directly transverse, except at the hyponomic sinus which is relatively shallow and occupies about one-third of the width of the conch.

ARCHIACOCERAS Foerste

Genotype: *Phragmoceratites subventricosus* d'Archiac and de Verneuil, Trans. Geol. Soc. London, ser. 2, 6, 351, pl. 30, figs. 1, 1A (1842); *Archiacoceras subventricosum* Foerste, Jour. Sci. Lab. Denison Univ., 21, 346, pl. 43, figs. 3 A, B (1926).

Conch with the siphuncle endogastric in location, almost in contact with the slightly concave vertical outline of the conch, this side being assumed to be ventral. The opposite or dorsal outline is more strongly curved, in a convex direction. The maximum diameters of the conch, both dorso-ventrally and laterally, are about 9 camerae below the top of the phragmacone. From this level the conch contracts in an upward direction not only along the upper part of the phragmacone but also along all of the living chamber, as far as known. Of the living chamber a length equal to about 6 camerae is preserved, but there is no trace within this length of transverse markings by means of which the former locations of the hyponomic sinus could be determined, nor is there any trace at the top of the living chamber of any abrupt contraction, as in the typical phragmoceroids. The siphuncle is relatively large and strongly nummuloidal, its segments being low but broad and disk-like. The interior of the siphuncle is occupied by vertical lamellae projecting from the walls of the siphuncle toward its interior, but leaving a large space occupied only by matrix at its center. The sutures of the septa curve slightly downward laterally, but rise increasingly upward from the ventral toward the dorsal side of the conch, on approaching the upper part of the phragmacone. From the Middle Devonian of the Eifel, in Germany.

10. **Archiacoceras subventricosum** d'Archiac and de Verneuil

Plate XLIII, fig. 3

Phragmoceratites subventricosus d'Archiac and de Verneuil, Trans. Geol. Soc. London, ser. 2, 6, 351, pl. 30, figs. 1, 1A (1842); figure copied in reduced form by Foerste in Jour. Sci. Lab. Denison Univ., 21, pl. 43, figs. 3A, B (1926).

Specimen 145 mm. long, including the upper part of the phrag-

macone for a length of 15 camerae, and also the basal part of the living chamber. The siphuncle is located near that side of the conch which presents a concave vertical outline. This outline has a radius of curvature of 105 mm., except at the extreme top of the phragmacone and along the basal part of the living chamber where the radius of concave curvature becomes greater. The opposite or antisiphonal part of the conch presents a convex vertical outline with a radius of curvature of approximately 120 mm. The dorso-ventral diameter of the specimen enlarges from 90 mm. at its base to 96 mm. at the ninth or tenth camera beneath the living chamber, and then contracts to 88 mm. at the top of the phragmacone. In consequence the conch appears distinctly humped along its convex outline at a point nine or ten camerae below its living chamber. The cross-section of the conch is oval, being distinctly broader along its concave vertical outline, and more narrowly rounded along its convex vertical outline. Where the dorso-ventral diameter is 96 mm., the lateral outline is 80 mm., narrowing thence to 71.5 mm. at the base of the living chamber. It is this contraction of the upper part of the phragmacone for a considerable length, associated with the endogastric location of the siphuncle, which characterizes the genus *Archiacoceras*. Where the dorso-ventral diameter is 96 mm., the maximum lateral diameter of the conch is located 60 mm. from the convex vertical outline of the specimen. The number of camerae in a length of 96 mm. equals 9, when counted along this convex outline. Along the concave vertical outline these 9 camerae occupy a length of only 33 mm. At the base of the specimen the sutures of the septa are almost at right angles to the tangent of the concave vertical curvature at this point. At the maximum dorso-ventral diameter of the conch, these sutures rise at an angle of 10 degrees above a directly transverse line from the concave toward the convex vertical outline of the conch. At the top of the phragmacone this angle increases to at least 30 degrees. The sutures of the septa curve slightly downward laterally, the amount of this curvature usually not exceeding 2 or 3 mm. in depth, but on approaching the convex vertical outline there is a faint tendency toward reversal of curvature. The concavity of the septa at

mid-length of the specimen is about 9 mm. The specimen has been sectioned vertically in a dorso-ventral direction along its lower end for a length of 40 to 43 mm. At the base of the part thus exposed, the siphuncle is 1 mm. distant from the concave vertical outline of conch, increasing to 2.2 mm. at a point 28 mm. farther up. The dorso-ventral diameter of the segments of this siphuncle increases from 15 mm. at the base of the specimen to 21.5 mm. at the seventh segment above the base, the interval being 28 mm. when measured along that side of the siphuncle facing the interior of the conch. Above this level the siphuncle contracts to 20 mm. for a length of 3 consecutive segments, but whether this contraction continues farther upward is unknown, this part of the specimen not having been sectioned. Where the diameter of the siphuncle is 17 mm., the passage through the septum beneath is 9 mm., the contraction being 3 mm. on the side of the siphuncle facing the concave outline of the conch and 5 mm. on the opposite side. The height of the segments here varies between 4 and 5 mm. on the two sides just mentioned. The septal necks are extremely short, the light colored matrix embraced by the abruptly reflected part of the neck having a height of about one-tenth of a millimeter. The upper part of the connecting rings curves upward sufficiently to come in contact with the lower surface of the overlying septum. These septal necks are much more readily recognized along the side of the siphuncle facing the concave vertical outline of the conch than along its opposite side, some of the septa on this opposite side apparently terminating abruptly without any recurvature corresponding to a neck. The structure of the siphuncle is actinosiphonate. In cross-section it presents the appearance of vertical lamellae extending from the walls of the siphuncle toward its interior. Where the diameter of the siphuncle is 19 mm. there are 25 of these primary lamellae and a few secondary ones. The primary lamellae extend inward for a distance of 5 mm., leaving a central space of 9 mm. in diameter which is occupied only by the matrix. In vertical section these lamellae are seen to be attached to the horizontal parts of the connecting rings, where in direct contact with the inner margins of the septa. Evidently these converging

vertical lamellae correspond in structure to the radiate structure so often seen in transverse sections of typical actinoceroids. The difference consists chiefly in this: in typical actinoceroids the radiating elements are in lateral contact so that the entire inner wall of the siphuncle is lined with a laterally continuous deposit; in the actinosiphonate species, on the contrary, these radiating elements are distinctly separated from one another laterally, the intermediate spaces being occupied by matrix. In both cases, the radiating elements embrace the inner margins of the septal necks, and thence grow gradually inward and also upward and downward in a more or less lunate manner, as far as can be judged from the sections of *Archiacoceras* so far studied.

Occurrence.—Schiessberg Bruch, neat Sötenich, 15 miles southwest of Euskirchen, in the Eifel area of Germany; about 8 meters above the *Murchisonia* horizon, in the *Stringocephalus* zone of the Middle Devonian. Specimen in the museum of the Geological Survey, Berlin, Germany.

Remarks.—Several additional specimens of *Archiacoceras subventricosum* are present in the collections of the Geological Survey in Berlin. One of these, numbered 1680, retains a considerable length of the living chamber, approximately 6 or 7 camerae in length. Within this length the dorsal and ventral outlines of the living chamber continue the curvature of the corresponding outlines along the phragmacone, without any indication of phragmoceroid structure. Another well preserved specimen is numbered 1667. Both were found at Sötenich.

II. ORDOVICIAN CEPHALOPODS FROM NORTH-CENTRAL STATES

The determination of the stratigraphic position of the Red River formation of Southern Manitoba leaves much to be desired. Whiteaves regarded this formation as of Trenton age, especially that phase of the Trenton which is represented in the northern part of the Mississippi Valley, and which there is known as the Galena. The writer regards it as of Richmond age, but far more work will be necessary before this problem can be regarded as settled. Probably all of the faunas bearing on this question need restudy. As far as the cephalopods are concerned, we know too little of the cephalopods of Galena age.

In the hope of securing some information bearing on this subject the writer borrowed from Prof. C. R. Stauffer several specimens in the collections of the University of Minnesota which promised to shed light on this question. These specimens included those identified by Clarke as *Tripteroceras lambi* Whiteaves, and *Poterioceras apertum* Whiteaves, both being species originally described from the Red River formation; also *Oncoceras minnesotense* Clarke, a species whose siphuncle displays a type of structure identical with that of *Westonoceras*, a genus regarded as characteristic of the Red River formation, occurring not only in southern Manitoba but also in the area southwest of Hudson Bay and in southern Baffin Land; apparently also in northwestern Greenland. Studies of several species of *Tripteroceras* and *Gonioceras*, and one each of *Cameroceras* and *Trocholites* are added.

NANNO Clarke

Genotype: *Nanno aulema* Clarke, Amer. Geologist, 15, 207, pl. 6, figs. 1–8 (1894); Geol. Minnesota, 3, pt. 2, 770, pl. 47, figs. 4–11 (1897).

Conch enlarging rapidly at its apical end for a length of about 25 mm. and then much more slowly, both the ventral and the dorsal outlines being convex along the area where the change takes place. The siphuncle enlarges rapidly for a length of 20 mm. at its apical end, especially in a dorso-ventral direction, and then contracts conspicuously farther up, especially along its dorsal outline. The lowest camerae appear where the siphuncle begins to contract. That part of the siphuncle which is below the camerated part is called the preseptal cone. The ventral side of the siphuncle is in contact with the ventral wall of the conch for a width of about 3 mm., and therefore presents a smooth surface. Along the remainder of its circumference the siphuncle is crossed obliquely by the annulations produced by the septal funnels, their slope being downward in a dorsad direction. The preseptal cone is compressed laterally. Little is known about the camerated part of the conch, this part not being well preserved in the single camerated specimen studied by Clarke. The genotype is from Minneapolis and Chatfield, Minnesota, in the Decorah member of the Black River.

Since the description of the genotype three additional species have been described under the generic name *Nanno;* namely, *Nanno kingstonensis* Whiteaves from the Pamelia member of the Stones River at Kingston, Ontario, Canada, *Nanno noveboracum* Ruedemann from the Valcour member of the Chazyan near Chazy, New York, and *Nanno primaevus* Whiteaves from the Canadian at Marlborough, Ontario, Canada.

Holm referred to this genus also the species *Endoceras belemnitiforme* Holm and its mutation *elata* Holm, *Endoceras fistula* Holm, and *Endoceras pygmaeum* Holm. All are figured in the two Swedish publications here cited under *Suecoceras. Endoceras belemnitiforme* is from the Upper Red Orthoceras limestone of Sweden.

SUECOCERAS Holm

Genotype: *Endoceras barrandei* Dewitz. Holm, Om apicaländan hos Endoceras, Geol. Fören. i. Stockholm, Förenhandl., 18, pt. 5 (1896); also in Sveriges Geol. Undersökning, Ser. C, no. 163 (1896); On the apical end of Endoceras, Amer. Geologist, 19 (1897).

Conchs unusually narrow, long and slender. Dorsal outline gibbous, the maximum gibbosity being about 20 mm. above the apical end in the genotype. In some specimens this gibbosity of the conch is accompanied by a corresponding gibbosity of the siphuncle, the latter increasing in diameter dorso-ventrally for a length of 20 mm. and then decreasing more or less distinctly farther up. In other specimens the diameter of the siphuncle is more nearly uniform above the level of the dorsal gibbosity, diminution in the size of the siphuncle above this level being slight or absent. In those specimens in which the diameter of the siphuncle is more nearly uniform the dorsal gibbosity is caused by the convex curvature of the lower part of the conch in a dorsad direction, the conch becoming straight above the level of this gibbosity. No preseptal cone is present, the presence of camerae being indicated even at initial stages of growth of the conch. The genotype is from the Upper Red Orthoceras limestone in Sweden.

Holm referred to the genus *Suecoceras* also the species *Endoceras dux* Holm, *Endoceras gibbum* Holm, and *Endoceras papilla* Holm. The reference of *Endoceras inaequabile* Miller to *Suecoceras*, as was done by Foerste in 1910, evidently is in error.

Apical ends of Endoceratidae

Enough is known of the apical ends of Endoceratidae to indicate that several types of structure are present. One of these was described by Clarke under the generic name *Nanno*; another was described by Holm under *Suecoceras*. The most fruitful studies of the apical ends of species referred to *Nanno* and *Suecoceras* are those made by Holm, but Clarke made the first notable contribution. Ruedemann described another type of apical end under the name *Baltoceras pusillum*, from Valcour, New York, in the Fort Cassin beds of the Canadian. In Bassler's Bibliographic Index of American Ordovician and Silurian Fossils Holm's genus *Suecoceras* is referred to *Cameroceras*. Sardeson has studied the apical ends of the species of *Cameroceras* and *Endoceras* occurring in the Minnesota Ordovician. The cumulative results of all of these studies however, is not sufficient to determine to what extent the different structures are of diagnostic value in the determination of genera. Especially is this true of American species. In those few species in which the apical end is known the camerated part rarely is known sufficiently well to make generic reference certain beyond all doubt.

A similar condition prevails in the study of endocones. Here also several types of structure prevail which may prove eventually to be of diagnostic value. The writer has attempted to restrict the name *Endoceras* to those species in which the endocone is relatively long, slowly tapering, and without annulations, and the name *Cameroceras* for those species in which the endocones are relatively short and usually obliquely annulated in a direction parallel to the upper margin of the septal necks. Recently he has had the opportunity of studying the short endocones of various species of *Cameroceras* from various horizons in the Canadian belonging to the Ulrich collection in the U. S. National Museum. However, it rarely occurs that the same specimen of endoceroid

retains both the apical end and the endocone within the siphuncle. The writer knows of only one such specimen and that belongs to the Museum of Natural History in Berlin, the species being there referred to *Endoceras*.

It is not always easy to determine from a fragmentary specimen whether a particular specimen is to be referred to the apical end of a conch or to the endocone. Both continue upward into the normal siphuncle and the line of demarcation can not always be discovered. When the endocone occurs within the siphuncle of a conch which still retains its camerae, it may, of course, be identified readily. This is true also of an apical end when the preseptal cone is followed immediately by the camerated part. However, where the camerated part is lacking difficulties may appear. For the progress of our knowledge of the structure of the Endoceratidae it is very important that all available material bearing on the presence and structure of apical ends and endocones be published, especially in those cases in which the camerated part of the conch also is present. Should any specimen be found in which both the apical end and one of the endocones is preserved, its value would be still greater.

The preceding remarks are suggested by a specimen here described as *Cameroceras faberi*, of which only the apical end with the adjacent camerated part is known, the specimen not being long enough to retain the endocone. The only clue to its generic identity is furnished by its septal necks, which extend posteriorly only far enough to invaginate into the top of the septal neck immediately beneath. In addition there appears to be a continuous layer of shell lining the interior of the siphuncle, slightly lighter in color than the septal necks. According to Hyatt, this structure should be characteristic of *Cameroceras*, but the writer has not seen enough well preserved specimens to venture an opinion of his own.

11. Cameroceras (?) faberi Sp. nov.

Plate LXIII, fig. 2

Apical end of conch covered by an incrustation of a stromatoporoid, assumed to be *Stromatocerium montiferum* Ulrich, which

was described from the same locality and horizon. Specimen 85 mm. long, enlarging rapidly for a length of 35 mm. at an apical an le of about 40 degrees, and then much more slowly at an angle of about 6 or 7 degrees. At the top of the specimen its diameter is 33 mm., that of the siphuncle being 15 mm. The latter is in contact with the ventral wall of the conch for a width of 3 or 4 mm. and shows no distinct flattening along the contact zone. The concavity of the septa equals about 7 mm. About 7.3 camerae occur in a length equal to the diameter of the conch. The 7 upper septa and the 2 lower septa are well preserved, several of the 6 intermediate septa being indicated at their septal necks.

The most interesting feature is the structure of the apical end of the specimen. This enlarges rapidly for a length of 10 mm., consisting within this length only of the basal part of the siphuncle. Above this length the camerae are added, the height of the first two camerae differing but slightly from the height of those along the upper part of the specimen. Along the dorsal side of the siphuncle the camerae rapidly increase in diameter dorsoventrally for a length of 25 mm., and then much more slowly for the remainder of the specimen. The siphuncle is erect at its apical end for a length of 10 mm., curves outward in a ventrad direction for a length of 20 mm., and then becomes more nearly erect again for the remainder of its length, enlarging from a diameter of 10 mm. at 10 mm. above its base to 13 mm. at the point 20 mm. farther up, and to 15 mm. at the top of the specimen. The interior of the siphuncle is filled with crystalline calcite, the crystals converging toward the center of the siphuncle, and evidently deposited subsequent to the death of the animal.

Occurrence.—Madison, Indiana, in the Hitz layer, at the top of the Saluda member of the Richmond. Collection of Charles L. Faber, in whose honor the specimen is named.

Remarks.—The siphuncle of this specimen differs from that of typical *Nanno* in not contracting above that part called by Clarke the preseptal cone, and its cone differs from that of typical *Suecoceras* in not being gibbous along its dorsal outline a short distance above its base.

In typical *Endoceras inaequabile* Miller, as represented by figure

3 published by Miller, the siphuncle is gibbous along its dorsal side at a height of about 25 mm. above its base, contracting farther up. The ventral outline is straight except toward the base where it is slightly convex. The base of the specimen is figured as though crossed by oblique lines corresponding in character and distance to those left by the tops of the septal necks farther up. The structure of this specimen, as figured, is anomalous, and the type, which should be in the collections of the Chicago Academy of Science, deserves further study.

In *Endoceras bristolense* Miller, there appears to be a similar but more conspicuous gibbosity along the dorsal side of the siphuncle.

In *Endoceras egani* Miller, the siphuncle contains an endocone, relatively short and blunt, convex dorsally and flattened ventrally. This suggests a relationship nearer *Cameroceras* than *Endoceras*, the endocones of typical *Endoceras* being long and gradually tapering to a point.

All three of these species described by Miller are from Bristol, Illinois, in the Maquoketa member of the Richmond. The apical end of *Endoceras egani* is unknown. The type of *Endoceras bristolense* is described as though it consisted of a fragment of a siphuncle and part of an enclosed endocone. *Endoceras inaequabile* was founded on three specimens of siphuncles of which two were figured by Miller. His figure 3 apparently represents the apical end of a siphuncle, but it is figured as though surrounded by camerae even at its base, thus excluding the presence of a preseptal cone.

In the specimen figured by Foerste under the name *Suecoceras inaequabile* (Miller), from Clarksville, Ohio (Jour. Sci. Lab. Denison Univ., 16, pl. 1, fig. 1, 1910) the lower part of the specimen is crushed by lateral flattening so as to present a dorso-ventral outline similar to that of typical *Endoceras inaequabile* Miller. However, it is doubtful if the lower part of this specimen was gibbous dorsally as in the Maquoketa species just named. It was found at the base of the Clarksville division of the Waynesville member of the Richmond. The second specimen, represented by fig. 2 on the same plate, is from the same horizon at

Madison, Indiana. It is interpreted as an endocone. Another specimen (plate XLVIII, fig. 2), including an endocone projecting from beneath the basal one of a series of 5 camerae, belongs to the collection of Prof. W. H. Shideler.

TRIPTEROCERAS Hyatt

Genotype: *Orthoceras hastatum* Billings, Geol. Surv. Canada, Rep. of Progress for 1853–56, published in 1857, 333. See also Proc. Boston Soc. Nat. Hist., 22, 287 (1884); Foerste, Jour. Sci. Lab. Denison Univ., 20, 231, pl. 31, figs. 3 A-D (not figs. 2 A-D which illustrate *Allumettoceras pauquettense* Foerste), (1924); 21, p. 311 (1926).

The siphuncle of *Orthoceras hastatum* was described by Billings as "small, close to the center of the ventral margin." At a time when Hyatt studied the types of this species another specimen from the same locality and horizon had been added to the series of type specimens in which the siphuncle was distinctly larger and moniliform, while that of the original type series was narrow and tubular. In his description of *Tripteroceras*, founded on *Orthoceras hastatum*, Hyatt did not distinguish between these two types of structure, since at that time none of the original types had been cut so as to expose the tubular siphuncle. In fact, his description of the genus includes a description of the exterior of the conch of typical *Orthoceras hastatum* and a description of the siphuncle as exposed by the specimen added later. The latter was separated later by the writer under the name *Tripteroceras pauquettense* and the references to the figures on the accompanying plate 31 are correct in the text on pages 232 and 233, but in the description of the figures on plate 31 the name *hastatum* should be changed to *pauquettense*, and the name *pauquettense* to *hastatum*. In 1926 the writer limited the name *Tripteroceras* to species having the tubular siphuncle of typical *Orthoceras hastatum*, and proposed the name *Allumettoceras* for those with the much larger, moniliform siphuncle, as in *Tripteroceras pauquettense*.

12. **Tripteroceras planoconvexum** (Hall)

Orthoceras planoconvexum Hall, Rept. Superintendent of Geol. Surv. Wisconsin, 47 (1861); Whitfield, Mem. Am. Mus. Nat. Hist., 1, pt. 2, 72, pl. 8, figs. 24, 25; pl. 9, figs. 1, 2 (1895).

Specimen 35 mm. long, consisting of the lower part of a living chamber with 4 camerae still attached. At the base of the specimen its lateral diameter is 20 mm., enlarging to 23 mm. at the base of the living chamber, the apical angle being 16 degrees. The dorso-ventral diameter at the base of the specimen is 10 mm., enlarging to 12 mm. at the base of the living chamber, the apical angle in this direction being about 11 degrees. The ventral side of the conch is strongly flattened. The lateral sides tend to be more or less flattened for a width of 3.5 to 4 mm., and these sides converge slightly in a dorsad direction. The convexity of the dorsal side is about 5.5 mm. beyond that of the lateral sides, but there is a tendency toward angularity along its median part owing to the flattening of its dorso-lateral faces. The narrow lateral sides round evenly into the ventral and dorsal sides of the conch. The four camerae occupy a length of nearly 12 mm. when measured along the lateral outlines of the conch. From this it is estimated that about 9 camerae occur in a length equal to the lateral diameter of the conch. The suture of the septum at the base of the living chamber curves downward 5 mm. on the ventral side of the conch, there being a faint tendency toward reversal of curvature laterally. On the dorsal side of the conch they curve downward scarcely 2 mm., there being a very faint upward curvature medially, and a tendency toward reversal of curvature laterally. The septum at the base of the specimen curves downward nearly 3 mm. from the dorsal toward the ventral side of the conch. The center of the siphuncle is located 1.5 mm. from the ventral wall of the conch. Its diameter at its passage through the septum appears to be about 1.25 mm., but it is not outlined with sufficient clearness to give accurate measurements.

Occurrence.—Beloit, Wisconsin; in the Black River dolomite. Specimen no. 981, American Museum of Natural History; selected holotype.

Paratype.—Living chamber 63 mm. long, with one camera still attached. Cross-section similar to that of the type specimen, including the flattening of the lateral sides. However, the rate of enlargement of the conch in a lateral direction is only 11.5 degrees and the rate of downward curvature of the sutures of the septa is relatively greater. The lateral diameter of the living chamber is 32 mm. at its top and is estimated at about 19 mm. at its base. The specimen is slightly curved lengthwise, the convexity of its ventral outline being slightly over 1 mm. The ventral side of the specimen is crossed by relatively distant transverse lines, 4 mm. or more apart, in the form of narrow but distinctly incised grooves, interpreted as lines of growth of the shell, parallel to the transverse lines which are supposed to have ornamented the surface of the shell. These narrow grooves curve upward about half a millimeter in a width of 17 mm. where the lateral diameter of the conch is 25 mm., and also curve upward slightly on approaching the lateral outlines of the conch, for a width of 4 mm. on each side. Dorsally they curve slightly downward with a faint upward curve medially, and along the flattened lateral sides they apparently indicate low crests on the lateral margins of the aperture at successive stages of growth of the conch. Apparently the transverse lines were somewhat similar to the corresponding lines of those forms of *Geisonoceras* in which the bands are relatively crowded. About 12 low broad lines occur in a length of 10 mm. below the point where the lateral diameter of the conch is 25 mm. This is one of the few specimens of *Tripteroceras* in which the size of the living chamber is definitely known. Specimen also from Beloit, Wisconsin and numbered 981 in the American Museum of Natural History. From the Platteville member of the Black River.

A third specimen in the type series studied by Hall is a short fragment of the top of a living chamber 31 mm. in lateral diameter and only 20 mm. long, but showing very well the characteristic cross-section of the conch with its flattened narrow lateral sides.

13. **Tripteroceras** sp. (Hader)

Plate XLVIII, fig. 6

Tripteroceras planoconvexum Clarke, Geol. Minnesota, 3, Paleontology, pt. 2, 791, pl. 57, fig. 1 (1897).

Specimen 80 mm. long, consisting of a living chamber with 3 camerae still attached. The conch enlarges laterally at an angle of 13 degrees, its lateral diameter at the base of the living chamber being 44 mm., the corresponding dorso-ventral diameter being 17 mm. The cross-section of the conch is approximately lenticular, but with the dorsal side considerably more convex than the ventral one. At the base of the specimen the radius of transverse curvature of the ventral side is about 52 mm., while that of the dorsal side is about 25 mm. The 3 camerae at the base of the specimen occupy a combined length of 13 mm., suggesting the presence of 10 or 11 camerae within a length equal to the lateral diameter at the top of the series counted. The sutures of the septa curve downward a distance of almost 4 camerae ventrally and of 3 camerae dorsally, the septa sloping downward from the dorsal toward the ventral side. On the dorsal side of the conch the sutures of the septa rise without change of curvature as far as the lateral margins of the conch, but on the ventral side there is a slight reversal of curvature on approaching these margins. The passage of the siphuncle through the septum at the base of the specimen is 2.2 mm. in diameter dorso-ventrally and 3 mm. laterally, apparently indicating a dorso-ventral compression of the conch after the death of the animal. The center of the siphuncle is 3 mm. from the ventral wall of the conch. Nothing is known of the structure of the siphuncle.

Occurrence.—Hader, Minnesota; in the Fusispira and Nematopora beds forming the upper part of the Prosser limestone. Specimen in the collections of the University of Minnesota.

Remarks.—This specimen is not preserved well enough to serve as a type of a new species but it is readily separable from typical *Tripteroceras planoconvexum* by its smaller rate of expansion in a lateral direction, and its more lenticular cross-section. The ventral side of the cross-section is more convex; the lateral sides are

narrowly rounded instead of distinctly flattened; and its dorsal side is evenly rounded, instead of flattened dorso-laterally and subangular along its median line. Finally, the sutures of the septa curve more strongly downward.

14. **Tripteroceras oweni** Clarke

Plate XLVII, fig. 3

Triptoceras oweni Clarke, Geol. Minnesota, 3, pt. 2, 792, pl. 56, figs. 5, 6, 7 (1897).

Specimen 32 mm. long, enlarging in a lateral direction at an angle of 22 degrees. At the base of the specimen its lateral diameter is 10.5 mm. and its dorso-ventral one is 5.5 mm. At the top of the specimen, 30 mm. farther up, the corresponding diameters are 21 mm. and 12.5 mm. The ventral side of the conch is strongly flattened. The ventro-lateral angles are abruptly rounded, and the dorsal side is evenly convex, with no perceptible median angulation. The specimen is slightly curved lengthwise, its ventral side being convex in outline. The specimen apparently is a living chamber; at least, only one septum is indicated and that forms the base of the specimen. The suture of this septum curves strongly downward ventrally and dorsally. The septum slopes slightly downward in a ventrad direction. The passage of the siphuncle through this septum is located about two-fifths of a millimeter from the ventral wall of the conch. Its diameter also appears to be two-fifths of a millimeter. Nothing is known of the size or structure of the segments of this siphuncle, but, judging from the close proximity of the siphuncle to the ventral wall of the conch, it is assumed that its segments were narrowly elongated, as in the type of the genus Tripteroceras, namely *Tripteroceras hastatum* (Billings).

Occurrence.—Cannon Falls, Minnesota; in the Platteville member of the Black River formation.

15. **Tripteroceras scofieldi** Sp. nov.

Plate XLVII, fig. 4

Tripteroceras planoconvexum Clarke, Geol. Minnesota, 3, Paleontology, pt. 2, 791, pl. 56, fig. 3 (1897).

Specimen 52 mm. long, enlarging from a lateral diameter of 9.5 mm. at its base to 19 mm. at the base of the living chamber, the lateral apical angle being 20.5 degrees. Of the living chamber only the lower part, 30 mm. in length, is preserved. The side exposed is assumed to be the ventral one, chiefly because it is curved convexly in a lengthwise direction. In that case its transverse convexity is considerably greater than that of typical *Tripteroceras planoconvexum*, equalling nearly 2 mm. where the lateral diameter of the conch is 24 mm. The lateral margins of the conch appear to be narrowly rounded, rather than distinctly flattened. The number of camerae equals fully 11 in a length equal to the lateral diameter of the conch. The siphuncle is not exposed.

Occurrence.—Cannon Falls, Minnesota; in the Platteville member of the Black River formation. Specimen in the collections of the University of Minnesota; holotype.

Hader specimen.—Another specimen, apparently belonging to the same species is numbered 48382 in the U. S. National Museum, but is there recorded as from the Trenton at Hader, Minnesota. In this specimen the ventral and dorsal outlines of the cross-section are almost equally convex, the convexity of the dorsal side being slightly greater. The siphuncle is located close to the ventral wall of the conch, and its segments enlarge slightly within the camerae.

16. **Tripteroceras (?) planodorsatum** (Whitfield)

Plate XLVII, fig. 2

Cyrtoceras planodorsatum Whitfield, Geol. Wisconsin, 4, 231, pl. 7, figs. 10–12 (1882).

Triptoceras planodorsatum Clarke, Geol. Minnesota, 3, pt. 2, 792, pl. 56, fig. 4; pl. 57, figs. 2–4 (1897).

The type described by Whitefield was lost by fire with the remainder of his Wisconsin material, but his figures and description make known clearly such structure as its exterior presented. It is not a typical *Tripteroceras*, its lateral angles being much more broadly rounded, and its cross-section being more nearly semi-

circular than subtriangular in outline. Its cross-section is more similar to that of *Allumettoceras pauquettense* Foerste, and although the siphuncle is closer to the flat ventral side of the conch, it is possible that its structure was moniliform, as in that genus. The specimens figured by Clarke evidently belong to the same species, but the original of the figure 4 on plate 56 is missing. A description of the specimen represented by figs. 2, 3, and 4 on plate 57 follows.

Specimen 30 mm. long, enlarging in a lateral direction at an angle of 8 degrees. Almost the entire specimen belongs to the living chamber, part of a camera adhering at its base. The lateral diameter at its base is 11 mm., and its dorso-ventral diameter is 7.1 mm. The ventral side of the conch is strongly flattened and the lateral sides are broadly rounded, the dorsal side being convex but somewhat depressed medially. The septum at the base of the specimen curves strongly downward from the dorsal and lateral sides of the conch toward the median part of the ventral side. There appears to be a trace of a siphuncle near to the ventral wall of the conch, as in the figure presented by Whitfield. The faint lengthwise curvature of the conch in a dorso-ventral direction may be due to distortion after the death of the animal, though a similar curvature, with the convex outline on the ventral side, is shown by some specimens of *Tripteroceras*. No trace of surface ornamentation is preserved.

Occurrence.—Minneapolis, Minnesota; in the Platteville member of the Black River formation. Specimen no. 8299, in the collection of the Geological Survey of Minnesota deposited in the University of Minnesota.

WESTONOCERAS Foerste

Genotype: *Cyrtoceras manitobense* Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 80, pl. 13, figs. 3, 4, 5; pl. 15, fig. 4 (1890); *Westonoceras manitobense* Foerste, Jour. Sci. Lab. Denison Univ. 20, 253 (1924); 24, 219, pl. 38, figs. 2, 3 (1929); Contrib. Mus. Pal. Michigan Univ., 3, 49, pl. 5, fig. 1; pl. 11, fig. 5 (1928).

Conch enlarging fairly evenly as far as the fifth camera beneath

the living chamber and then contracting toward the aperture of the living chamber. Ventral side convexly humped at the maximum diameter of the conch, the outline above and below this hump being relatively straight. Dorsal outline nearly straight, or faintly gibbous at the point opposite the ventral hump. Sutures of the septa nearly straight along the lower part of the phragmacone, and sloping downward in a ventrad direction; more nearly horizontal along the upper part of the phragmacone and curving upward along its ventral side. Siphuncle near the ventral side of the conch but not in contact with the latter. The septa, where in contact with the connecting rings, do not curve downward to form septal necks, but are directly adnate to the segments of the siphuncle above and below, the vertical outlines of these segments being but moderately convex. Distribution chiefly in the Red River formation and its equivalents. However, the species described by Clarke under the name *Oncoceras minnesotense*, from the Prosser member of the Trenton at Hader, Stewartville, and elsewhere in Minnesota has an interior structure so closely similar to that of *Westonoceras* that the types were borrowed for further study.

17. **Westonoceras** (?) **minnesotense** (Clarke)

Plate XLVIII, figs. 3, 4

Oncoceras minnesotense Clarke. Geol. Minnesota, 3, pt. 2, 798, text fig. 10; pl. 58, figs. 16, 17, 18, 18a, 18b (1897).

Specimen 62 mm. long, enlarging dorso-ventrally from a diameter of 16 mm. to 37 mm. in a length of 44 mm.; the corresponding lateral diameters are 14 mm. and 29 mm. The ventral outline is faintly convex. The dorsal outline is slightly concave along the entire length of that part of the specimen which is preserved. The number of camerae in a length equal to the dorso-ventral diameter at the top of the series counted varies from 8 along the lower part of the specimen to 9 along its upper part. The sutures of septa are almost straight along the lower part of the specimen, but curve downward about 3 mm. at its top. The sutures of the lower septa slope slightly downward in a ventrad

direction, but at the top of the specimen the ventral saddles rise about 3 mm. higher than the dorsal ones. This suggests that the ventral axis of the phragmacone is slightly curved lengthwise, with the ventral side of the conch convex, though this side appears almost straight. The cross-section of the conch is slightly angular along the median part of the ventral side, and here the sutures of the septa form slightly angular saddles. The corresponding dorsal saddles are broader, more evenly convex, and less elevated. Between the ninth and tenth camera from the top of the specimen the phragmacone is broken across. At this break the dorso-ventral diameter of the conch is 19 mm., and the lateral one is 16.5 mm. The outline of the overlying segment of the siphuncle, as seen through the septum, is 5.2 mm. in diameter, and is 1 mm. or slightly more from the ventral wall of the conch.

Occurrence.—Lime City, Minnesota; from the *Fusispira* and *Nematopora* beds which form the upper half of the Prosser limestone. Specimen No. 258, in the University of Minnesota. The original of figures 16, 17, and 18 of plate 58, cited above.

The vertical dorso-ventral section illustrated by text figure No. 10 accompanying Clarke's original description of *Oncoceras minnesotense*, is from a specimen coming from the same locality and horizon as the preceding. This specimen is about 35 mm. long. At its top, where the dorso-ventral diameter is 29 mm., the diameter of the uppermost segment of the siphuncle is 5.5 mm., and its distance from the ventral wall of the conch is 2.2 mm. The septa do not form septal necks, but end abruptly at circular openings through the septa about 3 mm. in diameter. The segments of the siphuncle are in contact with the immediately overlying and underlying septa for a width of approximately 1 mm. Their ventral vertical outlines are more curved along the upper part of their course, and less curved along their lower half. Their dorsal outlines are more curved along the lower part of their course, but are approximately straight farther up. It is possible that figs. 18a and 18b on plate 58 accompanying Clarke's original description of this species were prepared from the exposures at the top and bottom of this specimen, which also is numbered 258 in the collections of the University of Minnesota.

Remarks.—The structure of the siphuncle of *Oncoceras minnesotense* is identical with that of typical *Westonoceras*. It may be a forerunner of the latter. Unfortunately not enough of the conch remains to determine whether this conch, when mature, was humped along its ventral outline, and contracted toward the aperture, as in typical *Westonoceras*. Under these circumstances its generic reference must remain in doubt until the upper part of the conch, with its living chamber, can be discovered.

DIESTOCERAS Foerste

Genotype: *Gomphoceras indianense* Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, 137, pl. 7, figs. 3–5 (1894). *Diestoceras indianense* Foerste, Jour. Sci. Lab. Denison Univ., 20, 263, pl. 25, figs. 1 A, B; pl. 26, figs. 1 A, B, 2 A, B; pl. 27, fig. 2 (1924).

Conch attaining its maximum diameter at or immediately below the base of the living chamber. Ventral outline convex. Dorsal outline gibbous at the base of the living chamber and the top of the phragmacone; straight or faintly concave along the lower part of the phragmacone, and faintly concave along the upper part of the living chamber. Aperture with a shallow hyponomic sinus along its ventral margin. Siphuncle located near the ventral outline of the conch, but not in contact with the latter; relatively large, but its structures not well understood. Distribution chiefly in the Richmond.

18. **Diestoceras clarkei** Sp. nov.

Plate XLVII, fig. 5

Poterioceras apertum Clarke, Geol. Minnesota, 3, pt. 2, 796, pl. 57, fig. 11 (1897).

Specimen 79 mm. long, the convexity of the ventral outline having a radius of 70 mm. The gibbosity of the dorsal outline has a radius of 55 mm. The maximum of this gibbosity is near the suture between the second and third camerae beneath the top of the phragmacone. Beneath this level the dorsal outline is almost straight. At 17 mm. above the top of this phragmacone the dorsal outline is distinctly though slightly concave. The

phragmacone includes 11 camerae, of which the lower two are only partially preserved. The dorso-ventral diameter enlarges from 27 mm. at the base of the ninth camera beneath the living chamber to 45 mm. at the base of the second camera, then contracts to 43.5 mm. at the base of the living chamber, to 37 mm. at a point 22 mm. above the dorsal part of the septum at the base of this chamber, and this diameter of 22 mm. continues as far as the aperture, which is 27 mm. above the base of the living chamber along the dorsal side of the conch and 30 mm. above ventrally. The maximum lateral diameter is estimated at 40 mm., the right side of the specimen being partially weathered away. The sutures of the septa are essentially straight, but they diverge slightly in a ventrad direction, 9 camerae occupying a combined length of 35 mm. along the dorsal outline of the conch, but 40 mm. ventrally. At the base of the specimen the sutures slope slightly downward in a ventrad direction; at the base of the living chamber they rise slightly in this direction. The siphuncle is located 2 mm. from the ventral wall of the conch. Nothing definite is known about the size or form of its segments.

Occurrence.—St. Paul, Minnesota; in the Galena shales. In the list of fossils published in part 2 of volume 3 of the Final volume of the Geology of Minnesota this species is listed from the *Fusispira* and *Nematopora* beds forming the upper half of the Prosser limestone. Specimen No. 5837, Univ. of Minnesota.

Remarks.—From *Diestoceras apertum* (Whiteaves) this species differs in its much smaller size and relatively taller living chamber. From *Diestoceras whiteavesi* Foerste, referred by Whiteaves to his species *apertum*, it differs in the conspicuous gibbosity of its dorsal outline.

GONIOCERAS Hall

Genotype: *Gonioceras anceps* Hall, Pal. New York, 1, 54, pl. 14, figs. 1 a–d (1847).

Conchs very much depressed ventro-laterally, forming broad, flat growths, usually relatively flat on one face and moderately convex on the other, these faces converging laterally to a thin edge. On both faces the sutures of the septa curve strongly

downward along their more median parts and rise laterally into conspicuous saddles before curving downward again before reaching the lateral outlines of the conch. The siphuncle is located about halfway between the two faces. In the vicinity of the siphuncle the septa curve moderately downward, the septal necks being almost absent, as in some species of *Armenoceras*. The segments of the siphuncle are low and broad, as indicated by Hall in his figure 1 of the genotype. The septa slope slightly downward in a ventrad direction. The surface of the shell is smooth. Usually only the flat side of the conch is well preserved, its more convex side facing upward in the rock, and showing more or less the effects of weathering or erosion. The genotype is from the Watertown member of the Black River, at Watertown, New York. *Gonioceras occidentale* is from the immediately underlying Platteville, at Platteville, Wisconsin. *Gonioceras chaziense* Ruedemann is from the Crown Point member of the Chazyan, at Chazy, New York. As far as known, no specimens of *Gonioceras* occur in the Richmond, its place there being taken by *Lambeoceras*.

19. **Gonioceras occidentale** Hall

Plate XLVI, fig. 1

Gonioceras occidentalis Hall, Rept. Supt. Geol. Surv. Wisconsin, 47 (1861); Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 72, pl. 12, fig. 2 (1895).

Specimen 115 mm. long, exposing its flat dorsal side. The middle or body part of the conch enlarges laterally from a diameter of 46 mm. at its base to 60 mm. at a point 48 mm. farther up, the angle of enlargement being 17 degrees. Where the lateral diameter of the middle or body part of the conch is 50 mm., that of the left wing is 27 mm. From this it is estimated that the lateral diameter of the entire conch at this point was 104 mm. If the same ratio of the lateral diameter of the wings to that of the middle or body part of the conch existed also at other levels along the conch, this would suggest an enlargement of the lateral diameter of the entire conch from 96 mm. at its base to 126 mm. at a point 48 mm. farther up, suggesting an angle of enlargement

for the entire conch of 36 degrees. The sutures of the septa curve strongly downward along the lateral parts of the body, forming broad lobes about 5 camerae in depth. These sutures rise strongly along the marginal parts of the body, and then curve rather abruptly outward along the proximal part of the lateral wings, rising slightly over a vertical distance of 1 mm. in a lateral extension of 6 mm. From this point they curve increasingly downward for a vertical distance of 17 mm. on approaching the lateral margins of the wings. These lateral margins are sharply acute. The dorso-ventral diameter of the conch is 15 mm. at the base of the specimen. The ventral side of the conch is broadly convex. Across the body of the conch this convexity appears to be moderate, increasing across the wings, the exterior margin of the latter being sharply acute, as already stated. The siphuncle is central in location. In its present condition of exposure, its lateral diameter is 10.2 mm. and its dorso-ventral one is 8 mm. However, only the lower face of the lowest segment is exposed, and at mid-height within the camera its diameter probably was a little larger. The septa curve dorso-ventrally as well as laterally. Along the median line of the conch they rise 3 or 4 mm. higher dorsally than ventrally.

Occurrence.—Platteville, Wisconsin; in the Platteville member of the Black River formation. Specimen No. 990–2, American Museum of Natural History.

Beloit specimen.—Specimen 55 mm. long, exposing the right half of the flat dorsal side of the conch and one side of the cavity left by the decay of the siphuncle. The body of the conch enlarges as rapidly as in the type of the species, and the sutures of the septa present a similar curvature across the lateral wings. Beloit, Wisconsin; in the Platteville member of the Black River formation. Specimen no. 990–1, American Museum of Natural History.

20. **Gonioceras occidentale homerense** Var. nov.

Plate XLV, fig. 1

Gonioceras occidentalis Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 72, pl. 12, fig. 1 (1895).

This specimen differs from the type of *Gonioceras occidentale* chiefly in its smaller rate of enlargement laterally. Other minor differences are noted, such as a tendency of the ventral side of the conch to be most convex along its median line, its lateral parts being more flattened. Moreover, there is tendency toward a vertical area of depression along the exterior half of the wings as viewed from this ventral side. To what extent these features are of specific value can not be determined until a greater number of specimens is at hand, indicating the degree of variation to be expected among members of the same species.

Specimen 165 mm. long. Of this length 75 to 80 mm. belongs to the living chamber. The dorsal side is flat, possibly faintly concave along the wings. The ventral side is convex, its greatest convexity being along the median line of the conch, the lateral parts being flattened, except along the exterior half of the wings, where their cross-section is distinctly concave. The middle or body part of the conch enlarges from 41 mm. at a point 40 mm. above the base of the specimen to 51 mm. at a point 47 mm. farther up, the angle of enlargement being 11 degrees. The vertical lines of depression along the middle of the wings diverge from 63 mm. at a point 52 mm. above the base of the specimen to 81 mm. at a point 70 mm. farther up, the angle of divergence being 15 degrees. Where the lateral diameter of the middle or body part of the conch is 42 mm., the width of the wings is at least 20 mm., and originally it may have been several millimeters broader. If this ratio between the lateral diameter of the wings and that of the middle or body part of the conch remains constant at other levels, then the rate of enlargement of the entire conch was about 24 degrees. The sutures of the septa follow a course closely similar to that of the type of *Gonioceras occidentale*, from Platteville, Wisconsin. At the base of the living chamber, where the lateral diameter of the middle or body part of the conch is 53 mm., the dorso-ventral diameter of the conch is about 20 mm. The outline of the aperture of the living chamber is uncertain. It appears to arch upward across both the dorsal and ventral sides of the conch, curving downward toward the acute lateral edges, but the supposed outlines of this aperture are not clearly defined. The surface of the shell is smooth.

Occurrence.—Homer, in La Salle county, Illinois; in the Platteville member of the Black River formation. Specimen No. 990–4. American Museum of Natural History.

21. **Gonioceras kayi** Sp. nov.

Plate XLVI, fig. 2

Specimen about 60 mm. long, exposing the flat dorsal side of the conch. Traces of the convex ventral side are visible along the top of the specimen. The maximum dorso-ventral diameter is 6 mm. Along the middle or body part of the dorsal side the sutures of the septa curve downward, forming broad lobes 3 camerae in depth. Along the line of junction between the body and the lateral wings of the dorsal side the sutures of the septa turn abruptly and diagonally downward, almost at a right angle to their course along the lateral parts of the body. Toward the exterior margins of the wings they curve increasingly downward. The lateral diameter of the middle or body part of the conch enlarges from 22 mm. at the base of the specimen to 27 mm. at a point 18 mm. farther up, the angle of enlargement here being 16 degrees. The relative width of the wings is estimated to have been 15 mm. where the width of the body was 28 mm. From this, the width of the entire conch at this point can be estimated at 58 mm. At the top of that part of the phragmacone which still remains the original width of the conch must have equalled 77 mm. The sutures of the septa crossing the middle or body part of the conch are slightly angulate along the median line of the body and also within 2 to 4 mm. of the lateral margins of this body. Possibly the body part of the dorsal side of the conch was faintly convex, changing to faintly concave along the proximal parts of the wings. The number of camerae in a length equal to the lateral diameter of the middle or body part of the conch, at the top of the series counted, is 8 or 9. The calcareous deposit within the camerae is confined chiefly to the dorsal side of the conch. Its thickness varies from 2 mm. at mid-height of the camerae to 3 or 4 mm. along the septa forming the top and bottom of each camera. Along the ventral side of the camerae these

calcareous deposits are more interrupted, appearing like serrations, each serration being formed by the deposit on the upper and lower side of one of the septa. The siphuncle is at least 2 mm. from the dorsal wall of the conch. Its location is assumed to have been central, but its exact diameter and distance from the ventral wall are unknown. Its interior appears to have been free from calcareous deposits, at least at the upper end of the specimen, which is the only part exposing the region traversed by the siphuncle.

Occurrence.—From Paint Creek township, in Allamakee county, Iowa; in the center of the western half of section 28. In the Guttenberg member of the Decorah formation, at about 22 feet above its base. Collected by George Marshall Kay. No. 8022, State University of Iowa collections.

Remarks.—*Gonioceras kayi* resembles *Gonioceras angulatum* Troedsson, from Cape Calhoun, in the northwestern part of Greenland, in the angularity of its dorso-lateral saddles, but these saddles are more rectangular. Moreover, its middle or body part expands at a more rapid rate laterally. It is doubtful if the angularity of the sutures of the septa along the middle and lateral part of their downward curving lobes is a constant feature of this species.

LAMBEOCERAS Foerste

Genotype: *Gonioceras lambii* Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 86, pl. 11, figs. 1 a, b (1892); Lambeoceras lambi Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 45 (1917); Jour. Sci. Lab. Denison Univ., 24, 213, pl. 34, fig. 1 (1929).

Conchs differing from *Gonioceras* chiefly in the sutures of the septa curving downward along the entire width of the conch, there being a slight outward curvature on approaching the lateral margins of the conch, but no up and down curvature as in the genus named. Both the ventral and dorsal faces of the conch are convex, but the convexity of the ventral face may be less than that of the dorsal one. The two faces meet laterally at an acute angle, but the latter is not thin and sharp, but blunt. The siphuncle is similar to that of *Gonioceras*, and the two genera

evidently are closely related. No calcareous deposits have been noted in the siphuncles examined so far. The genotype is from the Selkirk member of the Red River formation at East Selkirk, Manitoba, which is referred by the writer to the Richmond. *Lambeoceras richmondensis* Foerste is from the Whitewater member of the Richmond at Richmond, Indiana. The specimens of *Lambeoceras* described by Troedsson from the Cape Calhoun beds in northwestern Greenland are interpreted by him as of Richmond age. However, Clarke identified *Lambeoceras lambi* also from the Stewartville member of the Galena, at Stewartville, Minnesota, under its original name *Triptoceras lambi.* Hence the specimen figured by Clarke was borrowed for further study.

22. **Lambeoceras** cf. **lambi** (Whiteaves)

Plate XLVII, fig. 1

Triptoceras lambi Clarke, Geol. Minnesota, 3, pt. 2, 793, pl. 56, figs. 1, 2 (1897).

Specimen 190 mm. long, lenticular in cross-section. Apparently enlarging in a lateral direction at an angle of 16 degrees, but along one side of the specimen the outline is poorly preserved. In a similar manner, the dorso-ventral diameter of the conch can only be estimated. Where the lateral diameter is 96 mm., the dorso-ventral diameter appears to have been 32.5 mm., but both the dorsal and ventral sides of the conch are considerably weathered, so that the exact amount of convexity of neither side can be determined. The lateral angles appear rather abruptly rounded. Of the living chamber only the basal part, 60 mm. in length, remains. Fourteen camerae occupy a length equal to the lateral diameter of the conch at the top of the series counted. The sutures of the septa curve downward dorsally and ventrally for a distance of three and a half camerae. On the ventral side of the conch they curve downward a little more strongly, and in the immediate vicinity of the lateral margins of the conch they curve slightly outward, in a slightly sigmoid manner. The septa slope downward from the dorsal toward the ventral side of the conch. No trace of the siphuncle remains, the ventral side of the

conch being identified by the course of the sutures on approaching the lateral outlines and by the downward slope of the septa in this direction.

Occurrence.—Stewartville, Minnesota; in the *Maclurea* or Stewartville dolomite. Specimen No. 8293, University of Minnesota.

Remarks.—The specimen here described is the original of Clarke's figure 1. His figure 2 evidently was intended to represent a cross-section of the latter. Moreover, it represents a cross-section of a siphuncle in contact with the ventral side of the specimen, at least in its present condition. However, not a trace of such a siphuncle is presented by the original of his figure 1. Moreover, in his description of *Lambeoceras lambi* the siphuncle is described as "distinctly ventral and moniliform." The term moniliform was used by Hall in his description of the siphuncle of *Gonioceras anceps*. It should be noted, however, that Clarke's figure 2 does not leave room for a siphuncle having broad nummuloidal segments as in *Gonioceras anceps*. In fact, his figure leaves room only for a moderate enlargement of the siphuncle within the camerae, with the individual segments certainly not broader than they would be in a globular form. But, in the latter case the specimen described by Clarke could not be a *Lambeoceras*, but must belong to a distinct generic type, more nearly related to *Tripteroceras*. Unfortunately the second of the two specimens studied by Clarke can not be found. It may have presented some trace of the siphuncle, but that is doubtful, considering that no mention is made in the description of the figures presented by Clarke that they were made from different specimens. Therefore the writer is left with the opinion that the general appearance of the specimen described and figured by Clarke is closely similar to that of a *Lambeoceras*, but that the absence of definite knowledge of the structure of its siphuncle leaves this reference more or less in doubt. Moreover, the presence of *Oncoceras minnesotense* Clarke at Stewartville, and of *Maclurina manitobensis* Whiteaves in the Stewartville horizon makes it advisable that this Stewartville horizon be subjected to further study to determine whether its relationship is definitely with the Galena rather than with the Richmond.

TROCHOLITES Conrad

Genotype: *Trocholites ammonius* Conrad, 2nd Ann. Rep. New York Geol. Surv., 119 (1838); Hall, Pal. New York, 1, 192, pl. 40A, figs. 4 a-k (1847).

Conchs nautiloid, the volutions being in contact as far as the aperture. Dorsal contact zone impressed, the impression being wide but not deep. Cross-section reniform. Sutures of septa with distinct lateral lobes and large ventral saddles. Siphuncle near or in contact with the dorsal wall of the conch.

23. **Trocholites faberi** Sp. nov.

Plate LXIII, figs. 1A, B, C, D

Maximum diameter of conch across the umbilical depression 80 mm. The specimen consists of almost all of the outer volution and of less than half of the two immediately preceding volutions. In addition there is a natural cast of the lateral sides of the two outer volutions. Originally about four and a half volutions were present. The living chamber is slightly longer than half a volution. Near its aperture there is faint evidence of ventro-lateral flaring; however, since the aperture is not preserved, the amount of this flaring can not be determined. The dorsal contact zone of the conch is deeply impressed. At the base of the living chamber this zone is 12 or 13 mm. wide and a little over 1 mm. deep. The dorso-ventral diameter of the conch here is 13 mm., measured from the deepest part of the contact zone, and its lateral diameter is 23 mm. The general form of the cross-section is reniform, but with the maximum lateral diameter of the conch slightly ventrad of the center of the conch, the larger part of the lateral sides converging in a dorsad direction as far as the dorsal impressed zone. The sutures of the septa curve slightly downward dorso-laterally but curve strongly upward ventro-laterally, producing broad ventral saddles. About 4 camerae occur in a length equal to the lateral diameter of the conch. The siphuncle is almost 4 mm. in diameter and appears to be in contact with the dorsal wall of the conch. The shell is

relatively thick, especially along the living chamber where it equals or exceeds half a millimeter. The transverse striae are inconspicuous and not seen readily except under a lens. They curve downward ventro-laterally and indicate the former presence of a hyponomic sinus 4 mm. deep.

Occurrence.—West Covington, Kentucky; at the top of the Trenton, below the Dendrocrinus dyeri layer and above the Bromley shale. Collection of Charles L. Faber.

Remarks.—Compared with *Trocholites ammonius* Conrad, from the Trenton of New York, this conch is larger and the surface of the shell is not marked by salient transverse ribs and striae. Moreover, its siphuncle is much larger, and much closer to the dorsal wall of the conch, apparently being in contact with the latter. Named in honor of Charles L. Faber, who for many years has roamed over the hills and valleys of the area surrounding Cincinnati in search of fossils.

Joseph F. James cited *Trocholites ammonius* from the Cincinnati area and Bassler cited it from West Covington, Kentucky, in the Trenton; however, it is not probable that either citation is correct. The description by James follows, the italics being his own.

Shell discoidal volutions rounded, slightly concave on ventral-dorsal side, gradually enlarging towards aperture; *septa direct,* or *undulated* on dorsal-ventral side; *surface* with *more or less distinct irregular transverse striae* or ridges; outer chamber large; siphuncle central.

In this description he italicized the transverse striae but not the ridges, which may not have been present in his specimen, but which were present in the New York specimens on which the species was founded. Moreover, something is wrong with his location of the siphuncle, which never is central in any species of *Trocholites.* The terms ventral and dorsal are used at present in a sense opposite to that employed by many paleontologists at the time James wrote his paper, though not by Hyatt, whose Genera of Fossil Cephalopods is cited by James.

24. **Armenoceras saxosum** Sp. nov.

Plate XLVIII, fig. 1

Armenoceras sp. (Stony Mountain) Foerste, Jour. Sci. Lab. Denison Univ. 24, 204 (1929).

Contrasted with *Armenoceras richardsoni*, the segments of the siphuncle are a little taller, numbering 3.5 in a length equal to their diameter, instead of 4.5 as in the species named. Nothing is known about the surrounding part of the conch.

Occurrence.—Stony Mountain, Manitoba; in the Stony Mountain member of the Richmond group. The part of the siphuncle here figured on plate XLVIII is part of a longer specimen now broken into several fragments, and is preserved in the Victoria Memorial Museum, Ottawa, Ontario, Canada.

III. AMERICAN PHRAGMOCEROIDS AND GOMPHOCEROIDS

The following pages include a study of those American species of phragmoceroids and gomphoceroids which have already been described. An attempt is made to refer these species to those genera which were recognized by Hyatt in the Zittel-Eastman Text-book of Paleontology, some of these having been proposed by Hyatt in this textbook, and others having been proposed by him in 1882, almost fifty years ago. Some of these species were well described. In a few cases distinct species were incorrectly identified with others already described. In a few two distinct species were originally described under a single name. In these cases an attempt has been made to clear up the synonomy as far as possible. In those cases in which the types have been studied recently, new descriptions are offered. In other cases, only very brief indications of some of the more pertinent specific characteristics are offered. A few new species of *Phragmoceras* are described. No attempt is made to describe the numerous new species of gomphoceroids studied by the writer, since this new material, with one exception, does not offer anything of important taxonomic value. This one exception consists of a series of species evidently belonging to a new genus of gomphoceroids, for which the name *Stenogomphoceras* here is proposed, and the genotype described.

It is evident that the new genus of phragmoceroids proposed by Hedström in 1917, namely *Tubiferoceras*, has representatives in the Silurian of America. This led to a study of the numerous species of phragmoceroids and gomphoceroids preserved in the wonderful collection in the Riksmuseum at Stockholm, in Sweden, almost entirely from Gotland. It soon became evident that this Silurian of Gotland includes an abundant cephalopod fauna closely related to that described by Barrande from Bohemia. Almost all the generic types of phragmoceroids and gomphoceroids found in Bohemia occur also in Gotland, in addition to which Gotland offers generic types not recognized in Bohemia.

The Racine fauna of the north-central states of the United States and of the adjacent part of Ontario in Canada evidently could have reached America either from the Gotlandian areas of the Baltic regions or from the Bohemian areas of central Europe by a more southern path. Possibly both paths of migration were used, but the presence of species related to *Tubiferoceras* in northern Indiana and southeastern Wisconsin suggest that at least a part of this fauna entered by way of a northern route, starting from the Baltic regions of Europe.

It will be necessary to study the considerable quantity of undescribed material belonging to other groups of animal remains preseved in a fossil state in the Gotlandian strata of the Baltic areas before coming to a more definite conclusion as to the origin of our American Middle Silurian faunas.

PHRAGMOCERAS Broderip

Genotype: *Phragmoceras arcuatum* Sowerby, in Murchison's Silurian System, 621, pl. 10, fig. 1A (1839); Blake, British Fossil Cephalopoda, 204, pl. 20, figs. 1, 1A (1882); Foerste, Jour. Sci. Lab. Denison Univ., 21, 350, pl. 48, figs. 1A, B (1926).

In this genotype, the dorsal outline of the living chamber curves backward, giving rise to a short dorsal collar whose upper edge forms the margin of the dorsal expansion of the aperture. Conch strongly compressed laterally and strongly curved length-

wise. Ventral outline of living chamber curving strongly forward as far as the spout formed by the hyponomic sinus. Transverse striae curving slightly downward under the spout, but strongly downward dorsally. The general form of the dorsal expansion of the aperture is ovate, its ventrolateral sides converging at a more or less acute angle toward the narrowly contracted part of the aperture. Among American species of this type are the following: *Phragmoceras angustum, Phr. anticostiense, Phr. byronense, Phr. canadense, Phr. carmani, Phr. colliciare, Phr. cuneiforme, Phr. hespelerense, Phr. hoyi, Phr. hoyi compressum, Phr. lineolatum, Phr. nestor, Phr. parvum, Phr. raymondi, Phr. slocomi, Phr. vantuyli,* and *Phr. wilmingtonense.* In addition, the following species appear to belong to the same group, though nothing definite is known of the form of their apertures: *Phragmoceras accola, Phr. ellipticum, Phr. parksi, Phr. procerum, Phr. ruedemanni, Phr. whiteavesi,* and *Phr. whitneyi.*

Numerous other species have been included in *Phragmoceras* which differ considerably from the genotype. Hedström proposed in 1917 the name *Tubiferoceras* for those Swedish Gotlandian species in which the conch is erect instead of distinctly curved, and in which the shell grows inward along the base of the dorsal neck of the living chamber, forming a strongly elevated ridge which rises diagonally upward and inward. Among American species having this type of structure is the species originally described as *Trimeroceras gilberti.* The species originally described as *Gomphoceras linearis* and *Phragmoceras labiatum* also probably belong here.

In certain American species referred to *Phragmoceras* the anterior or ventral margin of the dorsal expansion of the aperture is more or less indented by the backward or dorsad growth of that part of the shell which borders on the narrowly contracted part of the aperture. In two of these species, *Phragmoceras auroraense* and *Phr. ontarioense,* the dorsal outline of this dorsal expansion of the aperture is weakly indented on each side of the median line of the dorsal side, thus resulting in a weakly trilobate dorsal outline along the dorsal neck. In several species, including *Phragmoceras chicagoense, Phragmoceras hillsboroense, Phragmoceras nel-*

sonense, Phragmoceras projectum and *Phragmoceras severnense,* the ventral margin of the dorsal expansion is indented, but no lobation has been detected so far along their dorsal margin. In all of these species the lateral diameter of the dorsal expansion of the aperture is considerably greater than its dorso-ventral diameter. Apparently *Phragmoceras altidorsatum* belongs to the second division of this group.

In the Swedish Gotlandian species *Phragmoceras acuminatum, Phr. discoideum, Phr. gigas, Phr. gradatum, Phr. liljevalli, Phr. parvulum, Phr. sigmoideum, Phr. simile,* and *Phr. undulatum* the anterior or ventral margin of the dorsal expansion is broadly indented, the lateral margins of this expansion curving diagonally downward and forward, thus indenting the upper posterior margin of the lateral sides of the living chamber. In *Phragmoceras inflexum* this indenting is narrowed to an almost horizontal slit. No American species having this type of structure are known, though the specimen of *Phragmoceras procerum* figured on Plate LIV suggests such an aperture. Unfortunately the state of preservation of this supposed postero-lateral indentation of the upper margin of the lateral walls of the living chamber is not known to have been present in the conch in its original form, there being a possibility that this indented appearance is deceptive, and due to the way the specimen broke in getting it out of the enclosing rock.

In general, the American species of *Phragmoceras* show a a closer relationship to those of Gotland than they do to those of Bohemia, although the Gotlandian fauna of Sweden is known to be closely similar to that of the Middle Silurian of the latter country.

Peebles dolomite.—On the following pages the term Peebles dolomite is used for that part of the Niagaran section which intervenes between the top of the Lilley formation and the base of the Greenfield dolomite in Highland and Adams counties. It contains the Guelph fauna of southern Ontario and north western Ohio. There is no single well exposed section of the entire formation but numerous exposures of different parts of the formation occur within several miles of Peebles, in Adams county, Ohio.

Usually the Lilley formation is absent, and the Peebles dolomite is in contact with the Bisher formation.

25. **Phragmoceras accola** Ruedemann

Plate LXII, fig. 1

Phragmoceras accola Ruedemann, New York State Mus. Bull., no. 189, 77, pl. 26, fig. 1 (1916).

Living chamber large, with a dorso-ventral diameter of 95 mm. at its base and a height of 80 mm. at the dorsal end of the narrowy contracted part of the aperture. The ventral outline of the chamber is gibbous below the level of the spout at the hyponomic sinus. The dorsal enlargement of the aperture is not preserved but is assumed to be similar to that of *Phragmoceras nestor*. The phragmacone is obliquely triangular on lateral view, its ventral outline being strongly concave, and scarcely equalling the ventral side of the living chamber in length. The dorsal outline of the entire conch is strongly convex.

Occurrence.—Schooley farm, Crane's Corners, town of Litchfield, Herkimer county, New York; in Bertie member of Upper Silurian, New York State Museum; specimen No. 12450–1.

26. **Phragmoceras altidorsatum** Sp. nov.

Plate LVII; fig. 3

Living chamber apparently belonging to a strongly curved species similar to *Phragmoceras colliciare*. Compared with the latter, however, the dorsal outline of this chamber is more erect, and the upper part of this outline is concave for a much longer distance; moreover, the upper outline of the chamber along the narrowly contracted part of the aperture slopes much more strongly downward. Compared with *Phragmoceras auroraense*, the living chamber here under discussion is much smaller, the concave outline along the upper part of its dorsal side occupies a much larger part of its total height, and the middle part of its ventral outline is more distinctly, though only slightly, gibbous.

Occurrence.—Cedarville, Ohio; in the Cedarville dolomite. In the U. S. National Museum.

27. **Phragmoceras angustum** (Newell)

Plate LVI, fig. 1

Gomphoceras angustus Newell, Proc. Boston Soc. Nat. Hist., 23, 475, fig., 1888.

Phragmoceras angustum Kindle and Breger, 28th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 477, pl. 18, fig. 1, 1904.

Conch relatively large and strongly curved lengthwise. The convex dorsal outline has a radius of curvature of 90 mm. from the fourteenth camera to the fifth camera beneath the living chamber, and then changes to a radius of 140 mm. to within 25 mm. of the aperture. The radius of curvature of the concave ventral outline is 25 mm. along the phragmacone, changing to 75 mm. along the living chamber. There is a tendency toward straightening along the ventral outline of the living chamber which in some specimens is very pronounced.

The dorso-ventral diameter enlarges from 51 mm. at the base of the thirteenth camera beneath the living chamber to 80 mm. at the base of the sixth camera, to 102 mm. at the base of the living chamber, and to 128 mm. along the upper part of this chamber between the dorsal extremity of the aperture and the proximal part of the spout-like projection at the hyponomic sinus. The lateral diameter is 22 mm. at the base of the thirteenth camera beneath the living chamber, and 61 mm. at the top of the phragmacone. The cross-sections of the conch are strongly elliptical, the dorsal side being strongly rounded, and the lateral sides only moderately convex, converging toward the subangular ventral side.

The height of the living chamber at the ventral end of the dorsal expansion of the aperture is 126 mm. This expansion slopes downward in a dorsad direction at an angle of 20 degrees with the horizontal plane passing through the suture of the septum at the base of the chamber. The narrowly contracted part of the aperture slopes at an angle of 25 degrees with the same plane in a ventrad direction, changing to 15 degrees on approaching the hyponomic sinus. The lower outline of the spout at this sinus extends 10 mm. beyond the ventral outline of the living chamber.

The lower part of the dorsal outline of this chamber slopes backward at an angle of 110 degrees with the basal plane just mentioned, and then curves forward at an angle of 80 degrees along the upper part of the chamber. The ventral outline slopes forward at an angle of 120 degrees. The aperture is assumed to be similar to that of *Phragmoceras nestor*, with an oval outline, its dorso-ventral diameter being 50 mm. The narrowly contracted part of the aperture is reduced to a width of 8 mm. or less along the greater part of its length, increasing to a width of 15 mm. at the spout-like projection of the hyponomic sinus. The lower part of the cast of the living chamber, at 6 mm. above the septum at its base, is marked by an annular groove, not strongly defined, locating the annular attachment ring along the inner wall of this chamber.

Along the dorsal outline of the conch the uppermost camera has a length of 10 mm.; the next six camerae in descending order average 17 mm. in length, the next two average 15 mm., and the next two about 12 mm. The sutures of the septa curve rather strongly downward laterally, rising in a correspondingly strong manner dorsally, slightly reversing in curvature on approaching the dorsal side of the conch. A similar reversal of curvature takes place on approaching the ventral outline. The siphuncle apparently is in contact with the ventral wall of the conch, but may be a short distance removed from the latter. Its dorso-ventral diameter in the seventh camera beneath the living chamber is 10 mm., constricted to 5.5 mm. where it passes through the septum. Since the lateral diameter of this constricted part is only 2 mm. it is evident that not only the siphuncle, but probably the entire conch is strongly compressed laterally in its present condition, evidently by pressure previous to fossilization.

Occurrence.—Wabash, Indiana; in the Liston Creek limestone member of the upper Niagaran. Specimen (plate LVI, fig. 1) No. 22861, Chicago University.

Marion specimens.—Specimen No. 3149, from Marion, Indiana, retains more of the spout-like projection at the hyponomic sinus. Specimen 3148, from the same locality, furnished the details in structure of the siphuncle in the preceding description. Specimen

No. 3145 retains traces of the transverse striae on the surface of the shell, about 11 in a length of 10 mm. along the ventrolateral half of one of the lateral sides of the living chamber. All are preserved in Ohio State University. The specimen figured by Kindle and Breger was obtained in Grant county, Indiana, probably from the vicinity of Marion.

The type was obtained at Wabash, Indiana. A series of paratypes is in the Boston Museum of Natural History, where they are numbered 11177–11180. Probably from the Mississinewa shale member of the upper Niagaran.

Remarks.—Different specimens show a moderate amount of variation in the height of the living chamber, the lengthwise curvature of the conch, and in the amount of downward curvature of the sutures of the septa along the lateral sides of the phragmacone.

Compared with the type of *Phragmoceras ellipticum*, this species is much larger; both the dorsal and ventral sides are more erect and the lateral sides probably were more convex originally. If the passage of the siphuncle through the septum at the base of the living chamber be viewed in a direction parallel to the ventral outline of the chamber, this passage appears to have a circular outline, suggesting the absence of lateral compression due to pressure after the death of the animal. In the case of *Phragmoceras angustum*, however, this passage remains compressed laterally when viewed in the same manner, suggesting that the conch of this species originally was considerably less compressed than it is at present.

28. **Phragmoceras anticostiense** Foerste

Phragmoceras anticostiense Foerste, in Twenhofel, Geology of Anticosti Island, Geol. Surv. Canada, Mem. 154, 320, pl. 58, fig. 1 (1927).

Conch cuneate in outline when viewed from the lateral side; very slightly curved lengthwise, the ventral outline being slightly concave. The dorsal lobe of the aperture apparently was similar to that of *Phragmoceras canadense*.

Occurrence.—Southwest Point, Anticosti Island, Canada; in

the Chicotte member of the Middle Silurian. Specimen No. 3878, Peabody Museum, Yale University; holotype.

29. **Phragmoceras auroraense** Sp. nov.

Plate LIII figs. 1A, B; 2A, B; 3

The largest specimen consists of the living chamber with 10 camerae attached, the uppermost camera being of small height. The convex dorsal outline has a radius of curvature of 50 mm. along the phragmacone, changing to 60 along the living chamber. The corresponding concave ventral outline has a radius changing from about 15 mm. along the phragmacone to a very slight curvature along the living chamber.

The top of the living chamber is depressed or flattened, forming an angle of 25 degrees with the suture at its base. The spout-like extension of the shell at the hyponomic sinus is not preserved. The narrowly contracted linear part of the aperture occupies the base of the slight depression which characterizes the median part of the flattened top of the chamber. The dorsal expansion of the aperture is broadly kidney-shaped, its outline being indented on each side of the proximal part of the narrowly contracted portion of the aperture by a dorsad extension of the adjoining part of the shell. The vertical corrugations at the base of the cast of the interior of the living chamber are strongly defined. The former presence of similar corrugations at earlier stages of growth of the conch is indicated by low, broad, faint vertical ribs, fairly distinct along the ventral side of the phragmacone but obsolete dorsally.

Near the base of the specimen the sutures of the septa are slightly concave, but toward the top of the phragmacone they become more distinctly concave, their maximum depth being located at two-thirds the dorso-ventral diameter from the ventral outline. The septa are rather strongly concave, having a transverse depth of 6 mm. at the fourth camera beneath the living chamber. In this camera the segment of the siphuncle has a lateral diameter of 3 mm. and a dorso-ventral one of 5 mm. parallel to the septa. The siphuncle is almost in contact with the ventral wall of the conch.

Occurrence.—Rising Sun, in Wood county, 26 miles south of Toledo, Ohio; in the Guelph member of the upper Niagaran. Specimen No. 7302, Ohio State University.

Remarks.—In general appearance this species closely resembles *Phragmoceras nestor*. However, the lengthwise curvature of its dorsal outline is less convex, the angle between the top and base of the living chamber is slightly greater, and the conch is much more compressed laterally, the ratio between the lateral and dorso-ventral diameters being as 33 to 50 mm. at the base of the living chamber. It is the difference in outline presented by the dorsal expansion of the aperture which is most characteristic, though shared by other species, such as *Phragmoceras hillsboroense*.

Bowling Green specimens.—One of these specimens (plate LIII, fig. 3), numbered 14809B at Ohio State University, shows a distinct though not deep trilobation of the dorsal outline of the broad, kidney-shaped dorsal expansion of the aperture at the contact of its collar with the remainder of the dorsal wall of the living chamber. This trilobation may be compared with the much more distinct trilobation shown by *Phragmoceras dentatum*, *Phragmoceras obesum*, and *Phragmoceras dubium*, all species described by Herman Hedström in his paper "Ueber die Gattung Phragmoceras in der Obersilurformation Gotlands (Sveriges Geologiska Undersökning, ser. Ca, no. 15, (1917)).

30. **Phragmoceras sp.** (Bacon Flat)

Plate LIV, figs. 2A, B

Living chamber 14 mm. in diameter dorso-ventrally and 11 mm. laterally at its base, enlarging slowly dorso-ventrally, and attaining a height of about 27 or 28 mm. Only the uppermost camera is preserved, and that is about 1 mm. in height. The suture of the septum at its base curves slightly downward. Characterized by its tall and slender growth, but the specimen is too poorly preserved to serve as a type, most of the upper part of the figure here presented having been restored in order to present the writer's idea of its original form.

Occurrence.—Adams county, Ohio, a quarter of a mile north

of the Bacon Flat school, two and a half miles northeast of Peebles; in the Peebles member of the Middle Silurian. Associated with the specimen of *Pentameroceras* here described and figured under *Pentameroceras* cf. *mirum*.

31. **Phragmoceras byronense** Worthen

Plate LXI, figs. 1 A, B

Phragmoceras Byronensis Worthen, Geol. Surv. Illinois, 8, 506, pl. 24, fig. 6 (1875).

Conch curved lengthwise, the lower part of its concave ventral outline with a radius of curvature of 65 mm. up to within 5 camerae from the base of the living chamber, changing to a radius of 100 mm. farther up. The dorso-ventral diameter increases from 28 mm. at the base of the specimen to 54 mm. at the base of the living chamber and to about 63 mm. at about the same level as the lower part of the spout formed by the hyponomic sinus. The conch is strongly compressed, the lateral diameter increasing from 20 mm. at the base of the specimen to 38 mm. at the base of the living chamber, and to 43 mm. at a point 20 mm. above the lowest part of the suture at the base of this chamber; 25 mm. farther up this lateral diameter is reduced to 35 mm., above which the lateral sides of the conch curve rapidly inward toward the narrowly constricted part of the aperture. The upper outline of this constricted part slopes downward in a ventrad direction at an angle of 35 degrees with a horizontal plane passing through the dorsal and ventral saddles of the suture at the base of the chamber. The dorsal end of this constricted part is 63 mm. above the lowest part of the suture mentioned. Only the proximal part of the spout at the hyponomic sinus remains. Of the dorsal neck, the only part remaining is its ventral end, where it connects with the constricted part of the aperture.

Seven camerae occupy a length equal to the dorso-ventral diameter at the top of the series counted, when this counting is done along the dorsal margin of the conch. Along the upper part of the phragmacone the sutures of the septa curve downward a distance equal to the height of one camera. Both at the dorsal

and ventrad ends of the sutures they tend to curve slightly outward. The base of the cast of the interior of the living chamber is grooved transversely immediately above this suture. This groove and the immediately overlying part of the cast are ribbed and grooved vertically for a height of 7 or 8 mm. above the basal suture.

Occurrence.—Rock Island, Illinois, probably erratic from some locality near Port Byron; from the Port Byron dolomite, stratigraphically directly above the Racine dolomite. Specimen no. 12100, Illinois State Museum, Springfield, Illinois; holotype. When this specimen was studied by Worthen, the constricted part of the aperture was still concealed by the matrix. Later, it was exposed by the writer.

32. **Phragmoceras canadense** Whiteaves

Plate LIV, figs. 1 A, B

Phragmoceras nestor canadense Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 1, 39, pl. 7, fig. 1 (not figs. 1a, 1b), 1884.

Conch enlarging rapidly dorso-ventrally, less rapidly laterally, erect, with lengthwise curvature very small; living chamber relatively low, its upper outline sloping but slightly downward in a ventrad direction. The convex dorsal outline has a radius of curvature of 80 mm. The ventral outline is slightly concave along the lower part of the phragmacone becoming almost straight or slightly convex along the living chamber. The lower part of the ventral outline of the living chamber slopes forward at an angle of 110 degrees with the plane of the suture at its base. Most of the contraction of the living chamber toward the aperture takes place at the top of the chamber which presents a flattened appearance vertically. The aperture is not well preserved but is assumed to have been similar to that of *Phragmoceras nestor* along its dorsal lobe. The annular ring at the base of the living chamber is about 3 mm. in height. On the cast of the interior of the chamber this ring shows 12 vertical crenulations in a width of 20 mm. These crenulations extend upward as faint vertical ribs for a length of 10 or 11 mm. In an opposite direction they

extend downward along the cast of the interior of the phragmacone as a series of vertical ribs. The suture of the septum at the base of the living chamber is slightly convex in an upward direction laterally. The third suture beneath this chamber is approximately straight, and those at a lower level are more or less distinctly concave.

Occurrence.—Durham, Ontario; in the Guelph dolomite. Specimen No. 2920, Victoria Memorial Museum, Ottawa, Canada.

Remarks.—This specimen differs from *Phragmoceras nestor* in its greater lengthwise curvature, more erect form, and lower living chamber, especially dorsally. The camerae are much shorter dorsally, and vary but slightly in height from their ventral toward their dorsal sides.

33. **Phragmoceras carmani** Sp. nov.

Plate LV, fig. 1

One of the large species of *Phragmoceras*. At the base of the living chamber the dorso-ventral diameter is 118 mm. and the lateral diameter is estimated at about 80 or 85 mm. On the ventral side of this chamber the distance from its base to the proximal end of the spout formed by the hyponomic sinus is 60 mm. and the distance to the top of this spout is 95 mm. From this it is evident that the complete living chamber must have been of large dimensions. The spout is only 20 mm. long, which is short for a conch of such large size. Immediately above the suture of the septum at the base of the living chamber there is a low annular elevation varying in height from 2 mm. on the ventral side of the chamber to 4 mm. on its dorsal side. Above this elevation there is a groove with a nearly uniform height of 5 or 6 mm. Vertical crenulations descend into this groove from above and extend more than halfway across the latter before becoming indistinct. There are 5 of these crenulations in a width of 19 mm.

The camera immediately beneath the living chamber is only 7 mm. in height on the dorsal side of the conch. The corresponding heights of the camerae beneath, in descending order, are

19, 23, 23, 23, 18, 15, 12, and 15 mm. The radius of curvature of the convex dorsal outline of the phragmacone is 115 mm. The corresponding radius of the concave ventral outline is 35 mm. at the smaller end of the phragmacone, changing to 40 mm. at its larger end. The result is that the length of the phragmacone on its ventral side is only three-tenths of its length dorsally. The sutures of the septa curve only slightly downward laterally, reversing slightly in curvature on approaching the ventral side.

The siphuncle is large. Its segments are nummuloidal, and strongly flattened vertically. In the sixth camera beneath the living chamber the lateral diameter of the segment is 10 mm., and its dorso-ventral diameter in a direction parallel to the septa is 14 mm. In the ninth camera beneath the chamber the dorso-ventral diameter of the segment is 8 mm.

In general appearance the living chamber of this species is figured here as though similar to *Phragmoceras nestor*, a much smaller species; but this is an assumption not warranted by the single specimen at hand, in which no trace remains of the dorsal expansion of the aperture. The ventral outline of the living chamber is slightly convex. The lower margin of the spout curves abruptly away from this ventral outline, almost at a right angle. At about three-fifths of the height of the living chamber the lateral sides of this chamber begin to curve inward so that the middle part of the length of the aperture is narrowly linear. As far as may be determined from the specimen at hand, the upper part of the lateral sides of the chamber forms an angle of about 40 degrees with the median dorso-ventral plane of symmetry of the conch. There is no flattened area along the top of the chamber, on each side of the narrowly linear part of the aperture, as in many other species.

Occurrence.—From some unknown locality in Greene county, Ohio, probably from Cedarville; in the Cedarville dolomite. Type numbered 10912, Ohio State University. Named in honor of Prof. J. E. Carman.

Remarks.—Compared with *Phragmoceras ellipticum* this species is much less compressed laterally. Compared with *Phragmoceras angustum* (Newell) the conch enlarges much more rapidly and its living chamber is shorter.

34. **Phragmoceras chicagoense** Sp. nov.

Plate LXIII, figs. 3 A, B; 4 A, B

Living chamber similar in size and form to *Phragmoceras altidorsatum*, but more erect, the dorsal outline less convex, and the ventral outline taller and more erect, compared with the suture of the septum at the base of the chamber. The dorsal expansion of the aperture is indented along its ventral side by the backward growth of that part of the shell which borders on the narrowly contracted part of the aperture. This feature is present in *Phragmoceras auroraense*, *Phr. hillsboroense*, and *Phr. ontarioense*, and probably was present also in *Phragmoceras altidorsatum*.

Occurrence.—Chicago, Illinois; in the Racine dolomite. Specimen no. 22922, Walker Museum, Chicago University.

35. **Phragmoceras colliciare** Sp. nov.

Plate LII, figs. 1 A, B; 2 A, B; 3 A, B

Only the upper 9 or 10 camerae remain attached to the living chamber (plate LII, figs. 2 A, B). On the dorsal side of the phragmacone the convex curvature of the vertical outline has a radius of 33 mm., changing to 26 mm. along the upper 3 camerae and along all of the living chamber, except just beneath the aperture where a reversal of curvature takes place for a length of 2 or 3 mm. The concave outline of the ventral side of the phragmacone has a radius of 10 mm., continuing for 3 mm. above the base of the living chamber. Above this level, the ventral outline of the living chamber becomes slightly convex as far as the proximal part of the spout-like prolongation of the shell at the hyponomic sinus, where the curvature reverses to concave again. This spout-like projection extends about 5 mm. beyond the general ventral outline of the living chamber. The conch widens from a lateral diameter of 16 mm. at the base of the specimen to 26 mm. at the base of the living chamber. The widest part of the living chamber, 28 mm., is located between 10 and 15 mm. above its base; above this point it narrows toward the aperture. The ratio of the lateral to the dorso-ventral diameter varies from 83

per cent at the base of the specimen to 79 per cent at the fourth septum beneath the living chamber, and to 76 per cent at the base of this chamber, thus indicating a more rapid enlargement of the dorso-ventral diameter of the conch than of the lateral diameter.

The height of the living chamber varies from three-fourths to four-fifths of the length of the dorso-ventral diameter at its base. The dorsal expansion of the aperture has a width of 19 mm.; it is almost circular, the ratio of the lateral to the dorso-ventral diameter being as 5 to 4. From this dorsal expansion the aperture continues in a ventrad direction as a narrowly linear constriction, 15 mm. long and about 1 mm. wide. At its ventral end this aperture widens moderately into an obpyriform outline along the upper part of the spout-like prolongation of the shell at the hyponomic sinus. The upper margin of the nearly circular dorsal expansion of the aperture forms an angle of 20 to 25 degrees with the flattened upper surface of the living chamber as seen on lateral view. The cast of the interior of this chamber is distinctly crenulated in a vertical direction at its base.

The sutures of the septa curve gently downward laterally, and rise gently both dorsally and ventrally, but more rapidly in a ventrad direction, there being a slight reversal of curvature on reaching the dorsal side. The maximum downward curvature of the sutures is located at one-third the dorso-ventral diameter of the conch from its ventral side. The siphuncle is 1 mm. from the ventral wall of the conch, its lateral diameter being 3 mm., and its dorso-ventral one equalling 4.5 mm. when measured parallel to the septa.

Occurrence.—Cedarville, Ohio; in the Cedarville dolomite; in the collection of the writer; two specimens (plate LII, figs. 2 A, B), including the holotype. Also at Wilmington, Ohio, Moodie quarry, at the same horizon; in the collection of Dr. L. D. Welch (plate LII, figs. 1 A, B), deposited in Wilmington college.

Remarks.—*Phragmoceras colliciare* is characterized by the low, dumpy appearance of its living chamber, its upper outline being nearly parallel to its base. This upper outline tends to be slightly convex along the narrowly constricted part of the aperture. The

dorsal outline of the conch is strongly convex, its maximum curvature being at the base of the living chamber rather than near mid-height of the latter, contrasting in this respect with *Phragmoceras nestor* and other related species.

Bowling Green specimen.—This specimen (plate LII, figs. 3 A, B) closely resembles *Phragmoceras colliciare*, but differs in its larger size, the relatively greater height of the living chamber, and the less abrupt expansion of the narrowly contracted part of the aperture into its nearly circular dorsal part. From Bowling Green, Ohio; in the Guelph member of the upper part of the Niagaran. Specimen No. 9442A, Ohio State University.

36. **Phragmoceras** (?) **corallophilum** Clarke

Phragmoceras sp. Hall, Pal. New York, 2, 351, pl. 78, figs. 3a, b (1852).

Phragmoceras corallophilum Clarke, 12th Ann. Rept. New York state geologist, 90 (1893).

Ventral outline of conch concave along the lower part of the phragmacone but convex along the upper part of the phragmacone and the living chamber. The dorsal outline appears to be convex as far as the aperture of the living chamber, there being no reversal of curvature a short distance beneath this aperture as in typical *Phragmoceras*. The narrowly contracted part of the aperture slopes strongly downward in a ventrad direction. The camerae are relatively numerous, and the sutures of the septa appear to curve only moderately downward laterally.

Occurrence.—Schoharie, New York; in the Cobleskill member of the Upper Silurian. Specimens no. 4058, 4059, New York State Museum; types.

Remarks.—The absence of any reversal of curvature of the dorsal outline of the upper part of the living chamber, from convex to concave, throws considerable doubt on the reference of this species to *Phragmoceras;* however, in the absence of any definite knowledge of the outline of the dorsal enlargement of the aperture it is impossible to determine its relationship more definitely. There is a possibility of its being a gomphoceroid, allied to *Hexameroceras*.

37. **Phragmoceras cuneiforme** Sp. nov.

Plate L, figs. 2, 3

Cyrtoceracone breviconic (plate L, fig. 3), enlarging much more rapidly in a dorso-ventral direction than laterally. Only 7 camerae remain attached to the living chamber. The convex curvature of the dorsal outline of the phragmacone has a radius of 40 mm. This curvature continues for a distance of 7 mm. above the base of the living chamber, then increases for a short distance, becomes slight for 19 mm., and finally reverses to concave for a length of 3 mm. directly beneath the aperture. The concave curvature of the ventral side of the phragmacone has a radius of 12 mm.; along the lower part of the living chamber this outline becomes almost a straight line which continues as far as the base of the spout formed by the hyponomic sinus. The lowest septum present has a dorso-ventral diameter of 15 mm., and a lateral one of 12 mm. The corresponding diameters at the base of the living chamber are 33 mm. and 23 mm. The greatest width of the living chamber is at its mid-height. The ventral side of the cross-section is almost angularly convex.

The lower parts of the dorsal and ventral outlines of the living chamber diverge at an angle of 65 degrees from each other. The upper surface of this chamber, along the narrowly contracted part of the aperture, forms an angle of 25 degrees with the suture at its base. The dorsal end of the aperture is widened into a nearly circular expansion, with a lateral diameter of 17 mm. and a dorso-ventral extension of 14 mm. From this circular expansion the aperture continues in a ventrad direction as a narrow linear slit not exceeding 1 mm. in width. The ventral continuation of the slit into a spout-like projection is almost entirely missing, only its proximal part being preserved.

The sutures of the septa are almost straight at the base of the living chamber but curve downward laterally along the middle of the phragmacone. The sutures rise on approaching the dorsal side of the conch but reverse slightly in direction before reaching the median part of this side. The siphuncle is almost in contact with the ventral wall of the conch. Its segments are nummuloi-

dal. Where their lateral diameter is 2 mm. their dorso-ventral diameter, parallel to the slope of the septa, is 4 mm. In cross-sections which are directly transverse to the central axis of the conch the outline of the siphuncle would be more nearly circular.

Occurrence.—Moodie quarry, in southern part of Wilmington, Ohio; in the Cedarville dolomite. Type in the Geo. M. Austin collection in the U. S. National Museum. Represented also in the Welch collection (plate L, fig. 2) deposited in Wilmington college.

Remarks.—*Phragmoceras cuneiforme* is distinguished from most other species of this genus by its strong lateral compression, the subcuneate outline of the upper part of the conch on lateral view, and the relative straightness of the sutures of its septa, especially at the base of the living chamber. It evidently is related to *Phragmoceras parvum* from which it differs chiefly by its much greater size, and its much more rapid expansion in a dorso-ventral direction.

38. **Phragmoceras ellipticum** Hall and Whitfield

Plate L, fig. 4

Phragmoceras ellipticum Hall and Whitfield, Geol. Surv. Ohio, Pal., 2, 152, pl. 8, fig. 11 (1875).

The type consists of the greater part of the living chamber, but almost all of its upper part is missing. At its base there is a remnant of the middle part of the uppermost camera, slightly over 2 mm. in height. The missing camerae belonging immediately beneath unquestionably were of much greater height. In contrast with most species of *Phragmoceras*, both the dorsal and ventral outlines of this chamber are remarkably erect, compared with a horizontal plane passing through the dorsal and ventral extremities of the suture at its base. The most distinctive feature preserved consists of the remarkable flatness of the lateral sides of the chamber, resulting in a relatively short lateral diameter. At the base of the chamber, where the dorso-ventral diameter is 82 mm., the lateral diameter is 39 mm. in its present state of preservation, but originally may have equalled 42 mm., one of the

lateral sides being weathered. Only the lower half of the proximal part of the spout-like projection formed by the hyponomic sinus remains. Nothing is known of the dorsal enlargement of the aperture, nor of the slope of the narrowly contracted part of the aperture. There is only a very faint trace of an annular attachment ring at the base of the chamber. Since the type is a cast of the interior of the chamber, the annular ring is indicated by a faint groove. The maximum distance of this groove from the suture of the septum at the base of the specimen is 2 mm. The vertical corrugations, so characteristic of this groove in many species, here are reduced to very faint traces, apparently 4 corrugations in a length of 5 mm. The siphuncle, at the base of the living chamber, has a dorso-ventral diameter of 11 mm. measured along the septum, its lateral diameter being 8 mm. The latter diameter is that of the siphuncle when viewed along its vertical axis and not perpendicular to the curving septum.

Occurrence.—Highland county, Ohio, associated with *Trimerella ohioensis*. Its exact origin is unknown. Prof. Edward Orton, who collected the type, mentions the presence of *Trimerella* on the farm of George Rhodes, 3 miles west of Sinking Springs, in Highland county, but it is not known that this is the locality at which the type in question was obtained. Its association with *Trimerella* suggests that its horizon was that of the Peebles dolomite, an horizon corresponding to the Guelph of southern Ontario. Specimen No. 3413, Ohio State University.

39. **Phragmoceras hedstroemi** Sp. nov.

Phragmoceras ellipticum Hedström (not Hall and Whitfield), Ueber die Gattung Phragmoceras in der Obersilurformation Gotlands, Sveriges Geologiska Undersökning, ser. Ca, Uppsatser och avhandlingar i 4:0, no. 15, 29, pl. 26, fig. 15; pl. 27, fig. 1 (1917).

Conch rather strongly curved, even along the living chamber, its ventral outline arching strongly forward. Dorso-ventral diameter at the base of this chamber 60 mm.; height of the chamber about 80 mm., the sutures of the septa at its base curving moderately downward. The dorsal enlargement of the aperture

apparently is very small and approximately circular in form, but its state of preservation is unsatisfactory.

Occurrence.—From one of the canals of Habblingbo, on the island of Gotland, Sweden; in the Middle Silurian. Museum of Natural History, Stockholm.

40. **Phragmoceras hespelerense** Sp. nov.

Plate LVIII, fig. 3; plate LX, fig. 3

Phragmoceras nestor canadense Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 1, 39, pl. 7, figs. 1a, 1b (not fig. 1), 1884.

Compared with the type of *Phragmoceras canadense* the living chamber here discussed is distinctly taller, especially dorsally, the outline at its top, along the narrowly contracted part of the aperture, sloping strongly downward in a ventrad direction. The dorsal outline of the chamber is slightly humped a little above mid-height. The suture of the septum at the base of the chamber curves strongly downward. These differences are sufficient to indicate a distinct species. About the only specific characteristics which *Phragmoceras hespelerense* has in common with *Phragmoceras canadense* are the small divergence of the ventral from the dorsal side of the living chamber, the general erectness of the chamber, and the length of the vertical ribs or corrugations at the base of the cast of the interior of the living chamber.

Occurrence.—Hespeler, Ontario; in the Guelph dolomite. Specimen No. 2919, Victoria Memorial Museum, Ottawa, Canada.

41. **Phragmoceras hillsboroense** Sp. nov.

Plate LI, figs. 1 A, B

Living chamber low, the top subparallel to the base, closely resembling that of *Phragmoceras wilmingtonense* on lateral view, but the ventral outline is more erect; the living chamber, when viewed from above, is more tumid, the dorso-ventral diameter is much shorter, and the dorsal expansion of the aperture has a very different outline. This outline evidently is much shorter in a dorso-ventral direction, and it is indented on each side of the

proximal end of the narrowly contracted part of the aperture by a dorsad prolongation of the adjacent part of the shell, very much as in *Phragmoceras auroraense*. The specimen is poorly preserved along the margin of this dorsal expansion of the aperture. There is no conspicuous angulation of the ventral side of the living chamber. The median part of the top of the chamber is rather narrowly depressed, and much narrower than in *Phragmoceras auroraense*, but the general appearance of this top is more or less tumid.

Occurrence.—Highland county, Ohio; presumably from the Peebles dolomite. Specimen No. 3414, Ohio State University.

42. **Phragmoceras hoyi** Whitfield

Phragmoceras Hoyi Whitfield, Geol. Wisconsin, 4, p. 300, pl. 19, figs. 4, 5 (1882).

Conch, including both phragmacone and living chamber, strongly curved and rapidly enlarging, the ventral outline curving strongly forward and forming a spout without a more or less abrupt change in direction as in the formation of the spout in most other species of Phragmoceras. The living chamber continues to enlarge laterally at about the same rate as the phragmacone for at least half the length of the chamber, and then converges rapidly toward the narrowly contracted part of the aperture, the top of the chamber being flattened vertically in the vicinity of this contracted part. The dorsal expansion of the aperture is similar to that of *Phragmoceras nestor*.

Occurrence.—Wauwatosa, Wisconsin; in the Racine member of the Middle Silurian. The types were destroyed by fire.

43. **Phragmoceras hoyi compressum** Whitfield

Phragmoceras hoyi var. *compressum* Whitfield, Geol. Wisconsin, 4, 301, pl. 20, fig. 3 (1882).

Differing from typical *Phragmoceras hoyi* chiefly in the distinctly greater lateral compression of the conch. The specimen figured retained a part of the narrowly contracted region of the aperture, the latter sloping strongly downward in a ventrad direction.

Occurrence.—Wauwatosa and Racine, Wisconsin; in the Racine member of the Middle Silurian. The type was destroyed by fire.

44. **Phragmoceras lineolatum** Whiteaves

Phragmoceras lineolatum Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 4, 265, pl. 34, fig. 2 (not figs. 1, 3), 1906; Foerste and Savage, Jour. Sci. Lab. Denison Univ., 22, 97, pl. 20, figs. 3 A, B; fig. 1 (1927).

Conch of relatively small size, strongly curved lengthwise and rapidly enlarging dorso-ventrally, the ventral outline being strongly concave both along the phragmacone and along the living chamber, projecting strongly forward, especially along the spout at the hyponomic sinus. The sutures of the septa are relatively straight, curving only slightly downward laterally.

Occurrence.—Falls of Ekwan river, southwest of Hudson Bay; in the Attawapiskat member of the Middle Silurian. Specimen No. 4404, Victoria Memorial Museum, Ottawa, Canada; selected type.

45. **Phragmoceras** sp. (Cedarville)

Plate LXI, fig. 3

Compared with *Phragmoceras lineolatum*, this conch is more strongly curved lengthwise, especially along the phragmacone. The living chamber is of smaller height, especially dorsally; in consequence the upper outline of this chamber slants much less strongly in a ventrad direction, as compared with the plane of the suture of the septum at its base. The ventral outline of the chamber is relatively straight, curves moderately forward until reaching the spout at the hyponomic sinus, which projects more abruptly forward. The suture of the septum at the base of the chamber curves more distinctly downward than in the type of *Phragmoceras lineolatum*. Specimen consisting of the cast of the interior of the living chamber and of the exterior of one side of the phragmacone.

Occurrence.—Cedarville, Ohio; in the Cedarville member of the Middle Niagaran.

46. **Phragmoceras nelsonense** Parks

Phragmoceras nelsonense Parks, Trans. Royal Canadian Inst., 11, 83, pl. 1, fig. 7; pl. 3, figs. 1, 2 (1915); Foerste and Savage, Jour. Sci. Lab., Denison Univ., 22, 93, pl. 19, figs. 3–6 (1927).

Conch with a comparatively abrupt bend a short distance below the top of the phragmacone, the living chamber being relatively erect and expanding only moderately in a dorso-ventral direction. The dorsal outline of the living chamber is relatively tall, and its upper outline along the narrowly contracted part of the aperture slopes strongly downward in a ventrad direction. The ventral outline of the chamber is slightly convex a short distance beneath the spout at the hyponomic sinus.

Occurrence.—From drift at the entry of Seal river into the Nelson river; from the Middle Silurian, probably from its Ekwan member. Specimens no. 316S, Royal Museum of Paleontology, Toronto, Ontario, Canada.

47. **Phragmoceras nestor** Hall

Plate LI, figs. 3 A, B

Phragmoceras nestor Hall, 20th Rep. New York State Cab. Nat. Hist., 347, 363, figs. 7, 8 (1868).

Type consisting of a living chamber with 4 camerae still attached, the uppermost being considerably shorter than the remainder. The convex dorsal outline of the specimen has a radius of curvature of 50 mm., reversing just beneath the aperture. The radius of curvature of the concave ventral outline of the upper part of the phragmacone and the basal part of the living chamber is about 13 mm.; above this level the ventral outline of the living chamber is almost straight as far as the base of the spout formed by the hyponomic sinus. The lateral diameter of the conch increases from 25 mm. at the base of the specimen to 37 mm. at the base of the living chamber, and to 45 mm. a little above mid-height of the latter.

The dorsal expansion of the aperture is almost circular, and is inclined at an angle of 150 degrees with the flattened top of the living chamber. Around this dorsal expansion the shell rises

into a short collar along which the interior of the shell is thickened. The middle, linearly contracted part of the aperture was at least 25 mm. long. The spout-like prolongation of this aperture is broken off. The upper, flattened part of the living chamber forms an angle of 28 degrees with the suture of the septum at its base. The base of the cast of the interior of this chamber is marked by vertical corrugations whose lateral outlines present a zigzag pattern.

The sutures of the septa curve distinctly downward laterally, their maximum downward curvature being located three-eighths of the dorso-ventral diameter of the conch from its ventral outline. From this point of maximum concavity the sutures rise slightly in a ventrad direction, but more strongly toward the dorsal side of the conch, there being a slight tendency toward reversal of curvature along the latter. The concavity of the septum at the base of the specimen equals 5 mm. The siphuncle is almost in contact with the ventral wall of the conch.

Traces of the surface of the shell indicate the presence of low, broad, rather indistinct, transverse markings, about 4 or 5 in a length of 5 mm. These curve downward beneath the spout of the hyponomic sinus, and also curve downward toward the dorsal side of the conch.

Occurrence.—Wauwatosa, Wisconsin; in the Racine dolomite. Type, numbered 2116 in the American Museum of Natural History.

Remarks.—*Phragmoceras nestor* is characterized by the considerable length of its dorsal outline, the latter being rather strongly convex. The septa are strongly concave.

48. **Phragmoceras ontarioense** Sp. nov.

Plate LVIII, figs. 2 A, B

Phragmoceras parvum Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 1, 41, pl. 7, fig. 2 (1884).

Compared with typical *Phragmoceras parvum*, the living chamber figured by Whiteaves under the same name is more erect and

taller, both dorsally and ventrally; the outline along the narrowly contracted part of the aperture slopes less strongly downward in a ventrad direction, and the ventral outline of the chamber diverges much less from its dorsal outline. Finally, the ventral outline of the dorsal lobe of the aperture is distinctly indented at its junction with the narrowly contracted part of this aperture by the dorsad extension of that part of the shell which borders on this narrowly contracted part; moreover, the dorsal outline of this dorsal lobe is slightly indented on each side of its median part, thus becoming faintly trilobate, at least on casts of the interior of the living chamber.

Occurrence.—Hespeler, Ontario, Canada; in the Guelph dolomite. Specimen no. 2916, Victoria Memorial Museum, Ottawa, Canada.

Remarks.—Compared with *Phragmoceras severnense* Foerste and Savage, the ventral and dorsal outlines of the living chamber diverge more strongly, the upper outline of the chamber along its narrowly contracted part slopes more strongly downward in a ventrad direction, and the suture of the septum at its base curves more strongly downward laterally.

Similar specimens occur in the Port Byron member of the Middle Silurian at Port Byron, in northwestern Illinois.

49. **Phragmoceras parksi** Foerste and Savage

Phragmoceras parksi Foerste and Savage, Jour. Sci. Lab., Denison Univ., 22, 95, pl. 21, figs. 1 A, B (1927).

Conch apparently related to *Phragmoceras wilmingtonense*, but larger, with the camerae relatively of smaller height, especially dorsally. Moreover, the ventral outline of the upper part of the phragmacone meets the suture of the septum at the base of the living chamber nearly at a right angle, instead of a distinctly acute angle as in the species named.

Locality and Horizon.—Severn river, southwest of Hudson Bay; in the Attawapiskat member of the Middle Silurian. Specimen no. 49 HB in the collection of T. E. Savage.

50. **Phragmoceras parvum** Hall and Whitefield

Plate L, figs. 5 A, B; plate LV, fig. 2

Phragmoceras parvum Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 151, pl. 8, fig. 10 (1875).

The type of this species (plate LV, fig. 2) consists of a living chamber with 3 of the camerae still attached. The uppermost camera has a maximum height of 1 mm., while the two underlying camerae have a height of 2.5 mm. One side of the aperture is preserved from the tip of the spout-like projection formed by the hyponomic sinus as far back as the groove outlining the proximal part of the circular expansion of the aperture at its dorsal end. The remainder of this circular expansion is missing. The annular ring at the base of the living chamber has a height of slightly over 1 mm. Since this type is a cast of the interior of the conch, the annular ring is indicated by a corresponding transverse groove, crossed by vertical corrugations, about 4.5 in a width of 5 mm. The lateral diameter of the siphuncle is 1.25 mm., the dorso-ventral one being 2 mm. if measured parallel to the septum at the base of the living chamber.

Occurrence.—Cedarville, Ohio, is the Cedarville dolomite. Specimen No. 5889, Ohio State University; holotype.

Wilmington specimens.—Breviconic cyrtoceracones of small size, not exceeding 50 mm. in length originally. In one specimen collected at Wilmington 4 camerae remain attached to the living chamber. The convex dorsal outline has a radius of curvature of 34 mm. extending along the phragmacone and all but the top of the living chamber, a reversal of curvature taking place directly beneath the aperture. The concave ventral outline has a radius of curvature of 10 mm. along the phragmacone and the lower part of the living chamber, this curvature becoming accentuated at the proximal end of the spout-like prolongation of the shell at the hyponomic sinus. In figure 5 B on plate L, the lower, unseptated part of the phragmacone is represented as worked out by Dr. Welch, but no structure remains at present to attest to the correctness of this interpretation, though probably correct.

The height of the dorsal side of the living chamber is consider-

ably greater than that of the ventral side, the flattened top of the chamber forming an angle of 20 to 25 degrees with its base. The dorsal expansion of the aperture is nearly circular and has a width of nearly 10 mm. From this expansion, the aperture extends ventrad as a long narrow slit, less than 1 mm. in width and fully 14 mm. long. At its ventral end this aperture expands into an obpyriform opening, along the top of a spout-like projection of the shell, formed by the hyponomic sinus. The collar around the nearly circular dorsal expansion of the aperture apparently is 2 mm. in height. The vertical crenulations at the base of the cast of the interior of the living chamber are present only occasionally, and usually are almost obsolete.

The sutures of the septa are almost straight or only faintly concave. The septa are moderately concave. The siphuncle is almost in contact with the ventral wall. Directly beneath the living chamber it is 1.5 mm. wide and 2 mm. long in a dorso-ventral direction, parallel to the septa.

The Wilmington specimens (plate L, figs. 5 A, B) were obtained in the Moodie quarry, and belong to the Welch collection, deposited in Wilmington college.

Remarks.—Compared with *Phragmoceras cuneiforme*, this species is considerably smaller, its rate of expansion in a dorso-ventral direction is considerably less and the ratio of the height of the dorsal side of the living chamber to the dorso-ventral diameter at its base is considerably greater.

51. **Phragmoceras procerum** Sp. nov.

Plate LIV, fig 3; plate LIX, figs. 1, 2

Specimen (plate LIX, fig. 1) consisting of a living chamber with 4 camerae still attached, strongly compressed laterally. At the base of the living chamber the dorso-ventral diameter is 106 mm., and its lateral diameter is estimated at 53 mm. The convexity of the lateral sides here has a radius of 90 mm., changing to 110 mm. just before the strong convergence of these sides toward the aperture begins. Along the dorsal side of the cross-section the radius of curvature is 20 mm., that of the ventral side being

slightly greater. The convex curvature of the dorsal outline has a radius of 200 mm., the corresponding concave curvature of the ventral outline having a radius of 130 mm. The living chamber is unusually tall, compared with its dorso-ventral diameter, and, considering this, the rate of deviation of its ventral from its dorsal outline is small. The narrowly constricted part of the aperture slopes downward at an angle of 20 degrees with the plane of the suture at the base of the chamber. The lateral sides of the living chamber diverge from a lateral diameter of 53 mm. at its base to 66 mm. at a point 40 mm. from its top, above which a vertical transverse section of the chamber is almost semicircular. The dorsal side of the living chamber is comparatively erect. The ventral side slopes moderately forward. Only the proximal end of the spout formed by the hyponomic sinus remains. The dorsal expansion of the aperture is assumed to have been similar to that of *Phragmoceras nestor*, but its outline is not definitely known.

The sutures of the septa curve distinctly downward laterally, with a slight reversal of curvature dorsally. The siphuncle is almost in contact with the ventral wall of the conch. The lateral diameter of its segments is 10 or 11 mm. within the camerae, contracting to 7 mm. at the septal necks. Dorso-ventrally, these segments have a diameter of 15 mm. parallel to the septa.

Occurrence.—Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2323, (plate LIX, fig. 1) Museum Comparative Zoology, Harvard University; holotype. The specimen numbered 2241 (plate LIV, fig. 3) came from the same locality and horizon and may belong to the same species. It appears to have a different type of dorsal expansion of the aperture, similar to the species *Phragmoceras acuminatum*, *Phr. discoideum*, *Phr. gigas*, *Phr. gradatum*, *Phr. liljevalli*, *Phr. parvulum*, *Phr. sigmoideum*, *Phr. simile*, and *Phr. undulatum* from the Middle Silurian of the island of Gotland, Sweden. However, neither specimen 2323 nor 2241 preserves the outline of the aperture so that its form can be determined without doubt. The phragmacone (plate LIX, fig. 2) numbered 2244 may belong to the same species, but this also is uncertain.

52. **Phragmoceras projectum** (Newell)

Gomphoceras projectum Newell, Proc. Boston Soc. Nat. Hist., 23, 476, text figs. (1888).

The ventral outline of the dorsal enlargement of the aperture is indented by the dorsad extension of that part of the shell which borders on each side of the narrowly contracted part of the aperture; however, this dorsad extension is relatively broad rather than narrow. The dorsal margin of dorsal expansion of the aperture is not preserved.

Occurrence.—Delphi, Indiana; in the Huntingdon dolomite member of the upper Niagaran. Specimen No. 11181, Boston Soc. Nat. Hist.; holotype.

53. **Phragmoceras raymondi** Sp. nov.

Plate LVII, figs 1, 2; plate LVIII, fig. 1

Conch very large, one of the giants of the genus. Three living chambers are at hand, attaining a height of 140 to 158 mm. above the sutures at their bases at the ventral end of the dorsal expansion of the aperture. Their maximum lateral diameter varies from 100 to 106 mm. The radius of curvature of the convex dorsal outline varies from 120 to 150 mm., the corresponding concave curvature of the ventral outline having a radius of 150 mm. Compared with the plane of the suture at its base, the dorsal outline of the chamber slopes slightly backward for about one-third of its length and then curves forward, as a result its general appearance is approximately erect or tilted slightly forward. The ventral outline slopes forward at an angle of 110 to 115 degrees. At a distance of 70 to 75 mm. from the suture, the ventral outline curves more rapidly forward at the proximal end of the spout formed by the hyponomic sinus. The latter is not preserved in any specimen. The narrowly contracted part of the aperture is 55 to 60 mm. long; at its dorsal end its sides diverge at an angle of 75 to 85 degrees until near the dorsal side of the living chamber, where they curve around rapidly, the dorsal side of the dorsal expansion of the aperture being distinctly flattened. The greatest lateral diameter of the living chamber is

at mid-height, the strong inward curvature of the top of its lateral sides beginning about four-fifths of its height above its base. The surface of the shell is transversely banded, these bands curving strongly downward dorsally. The septum at the base of the living chamber has a dorso-ventral curvature with a radius of 90 mm., changing to 60 or 70 mm. in a lateral direction. The center of the siphuncle is 12 mm. from the ventral wall of the conch; its diameter within the camerae is 15 to 17 mm., narrowing to a width of 6 mm. at its passage through the septa. Only the uppermost camera is preserved in any specimen retaining the living chamber.

Occurrence.—Wauwatosa, Wisconsin; in the Racine dolomite. In the order of their importance in furnishing diagnostic details the three specimens are numbered 2249B (plate LVIII, fig. 1), 2249A, and 2324 (plate LVII, fig. 1), in the Museum of Comparative Zoology, Harvard University.

Immature specimens.—The aperture of the living chamber of *Phragmoceras* is contracted only once during the life of the animal; namely, when it has attained its gerontic stage. Therefore, the earlier stages of the conchs should resemble *Protophragmoceras*. Two large specimens, numbered 2179 (plate LVII, fig. 2) and 2181, occur at Harvard University, both from Wauwatosa, Wisconsin. The first of these retains the immature form of living chamber and several camerae. If the interpretation here given is correct, this immature living chamber would have been occupied with camerae at later stages of growth, the contracted form of the aperture being its final stage. The surface of the shell of this specimen is strongly banded transversely.

54. **Phragmoceras ruedemanni** Sp. nov.

Phragmoceras parvum Clarke and Ruedemann, Mem. New York State Museum, 5, 99, pl. 21, figs. 1–8 (1903).

Compared with typical *Phragmoceras parvum*, the living chamber of the New York species is taller, especially along its ventral outline, and this outline inclines less strongly forward compared with the plane of the suture of the septum at its base. Compared with *Phragmoceras whiteavesi*, the upper outline of the chamber

along the narrowly contracted part of the aperture slopes more strongly downward in a ventrad direction; the dorsal outline is more convex; the convexity of the ventral outline of the living chamber continues downward for a distance of three or four camerae beneath this chamber before changing rather abruptly from convex to concave along the lower part of the phragmacone. The form of the dorsal lobe of the aperture of *Phragmoceras ruedemanni* is not known with certainty, but figure 4 among those published by Clarke and Ruedemann suggests the presence of a dorsal lobe similar to that of *Phragmoceras nestor*.

Occurrence.—Rochester, New York; in the Rochester phase of the Guelph member of the Middle Silurian. New York State Museum, Albany, N. Y.

55. **Phragmoceras severnense** Foerste and Savage

Phragmoceras severnense Foerste and Savage, Jour. Sci. Lab. Denison University, 22, 93, pl. 19, figs. 2 A, B, 1927.

Living chamber subquadrangular in outline on lateral view, its height approximately equalling its maximum dorso-ventral diameter. Both its dorsal and ventral outlines are almost erect. The dorsal neck which supports the dorsal expansion of the aperture inclines abruptly backward for a length of 4 or 5 mm. and at an angle of about 45 degrees. This dorsal expansion of the aperture is 12 mm. wide and 8 mm. long dorso-ventrally. Its ventral outline is rather broadly indented by the dorsad extension of that part of the shell which borders on the sides of the narrowly contracted part of the aperture. There is no evidence, however, of a slight trilobation of the dorsal outline of the dorsal expansion of the aperture, as in *Phragmoceras ontarioense*, although better preserved specimens may show such a trilobation.

Occurrence.—Severn river, southwest of Hudson Bay; in the Severn member of the Middle Silurian. Specimen No. 48 HB, in the collection of T. E. Savage.

56. **Phragmoceras slocomi** Sp. nov.

Plate LX, fig. 1

The type consists of a living chamber with 35 camerae still attached. The height of this chamber from its base to the dorsal

end of the narrowly contracted part of its aperture is 70 mm. Its dorso-ventral diameter at the base of the chamber is 62 mm. In its present condition the conch is strongly compressed laterally, partly owing to flattening due to pressure previous to fossilization. Hence its original lateral diameter may have been 30 mm., though at present it is only 20 mm. The conch is strongly curved lengthwise, especially toward the smaller end of the specimen. Along its dorsal outline the radius of curvature is 35 mm. along the 18 lowest camerae, changing to 75 mm. along the next 12 camerae, and to 115 mm. along the 5 upper camerae and along the living chamber. The narrowly contracted part of the aperture slopes downward in a ventrad direction at an angle of 28 degrees with the plane of the suture at the base of the living chamber. The spout-like projection of the chamber at its hyponomic sinus extends outward about 7 mm. The dorsal lobe of the aperture is not clearly defined but appears to extend upward and backward, its outline being ovate as in *Phragmoceras nestor*. The camerae are relatively numerous, 11 to 13 occupying a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa curve downward along the lateral sides for a distance of 6 mm. along the upper part of the phragmacone. Toward their dorsal ends these sutures slightly reverse in curvature. The reversal in curvature is less distinct ventrally.

Occurrence.—Lannon, Wisconsin; presumably from the Waukesha member of the Niagaran. Collected by A. W. Slocom, curator of Walker Museum, Chicago University.

Remarks.—This species resembles *Phragmoceras angustum* in its strong lengthwise curvature and in the rate of divergence of the dorsal and ventral outlines of the living chamber. It differs chiefly in its much smaller size and in the relatively greater number of its camerae within a length equal to the dorso-ventral diameter of the conch at the top of the series counted.

Joliet specimen.—A specimen, consisting of the lower part of the living chamber to which 21 camerae still are attached, resembles *Phragmoceras slocomi* in its size and its strong curvature. At the base of the living chamber its dorso-ventral diameter is

62 mm. and its lateral diameter is estimated at 30 mm. The number of camerae within a length equal to the dorso-ventral diameter is 13. Joliet, Illinois; in the Joliet member of the Niagaran. Specimen No. 22965, Walker Museum, Chicago University.

57. **Phragmoceras vantuyli** Foerste and Savage

Phragmoceras vantuyli Foerste and Savage, Jour. Sci. Lab. Denison Univ., 22, 100 (1927).

Compared with *Phragmoceras anticostiense* Foerste, the general outline of this species on lateral view is closely similar, but the conch is more compressed laterally. The dorsal outline is straight and the ventral outline is but slightly concave until the proximal end of the spout at the hyponomic sinus is reached, which projects strongly forward. The dorsal enlargement of the aperture appears to have been similar to that of *Phragmoceras nestor.*

Occurrence.—Ekwan river, southwest of Hudson Bay; in the Attawapiskat member of the Middle Silurian. Specimen no. 52 HB in the collection of T. E. Savage.

58. **Phragmoceras whiteavesi** Foerste and Savage

Phragmaceras lineolatum Whiteaves (in part), Geol. Surv. Canada, Pal. Foss., 3, pt. 4, 265, pl. 34, fig. 1 (not figs. 2, 3) (1906).
Phragmoceras whiteavesi Foerste and Savage, Jour. Sci. Lab. Denison Univ., 22, 98, pl. 20, fig. 2 (1927).

Conch apparently closely similar to *Phragmoceras lineolatum*, especially in the general outline of its living chamber on lateral view; differing greatly, however, in the much stronger downward curvature of the suture of the septum at its base laterally.

Occurrence.—Middle rapid of the Falls of the Ekwan river, southwest of Hudson Bay; in the Attawapiskat member of the Middle Silurian. Specimen No. 4405a, Victoria Memorial Museum, Ottawa, Ontario, Canada.

59. **Phragmoceras whitneyi** Parks

Phragmoceras whitneyi Parks, Trans. Royal Canadian Inst., 11, 77, pl. 3, fig. 5; pl. 6, fig. 2; Foerste and Savage, Jour. Sci. Lab. Denison Univ. 22, 99, pl. 22, fig. 1 (1927).

Compared with *Phragmoceras angustum*, *Ph. carmani*, and *Ph. procerum*, the suture of the septum at the base of the living chamber of *Phragmoceras whitneyi* curves much more strongly downward laterally and the ventral outline of this chambers is more strongly concave and curves more strongly forward on approaching the spout at the hyponomic sinus.

Occurrence.—Limestone rapids in the Severn river, in either the Ekwan or the Attawapiskat member of the Middle Silurian. Specimen no. 318S, Royal Ontario Museum of Paleontology, Toronto, Ontario, Canada.

60. **Phragmoceras wilmingtonense** Sp. nov.

Plate L, fig. 1

Cyrtoceracone breviconic, rapidly expanding, especially in a dorso-ventral direction. Attached to the living chamber is one short camera, beneath which are four camerae of ordinary size, and part of an additional camera. The convex curvature of the dorsal outline of the phragmacone has a radius of 55 mm., changing to 40 mm. along the living chamber, and reversing beneath the aperture. The ventral outline of the phragmacone is slightly concave, changing to slightly convex along the lower half of the living chamber, reversing again beneath the proximal part of the spout formed by the hyponomic sinus.

The dorsal expansion of the aperture is large and almost circular. It is inclined at an angle of 150 degrees with the flattened top of the living chamber. The height of the collar around this dorsal expansion of the aperture is unknown. The middle, linearly contracted part of the aperture is 30 mm. long. The spout-like prolongation of the aperture at the hyponomic sinus is broken off. The flattened top of the living chamber forms an angle of about seven degrees with the plane of the suture of the septum at the base of this chamber. The basal part of the walls

of this chamber is marked by short vertical crenulations, continuing upward as much fainter markings.

The sutures of the septa are remarkably straight. The septa are only moderately concave from front to rear, the concavity in a lateral direction equalling 4 mm. The siphuncle is about 1 mm. from the ventral wall. The nummuloidal segments between the septa are 3 mm. in width, but longer in a direction parallel to the septa.

Occurrence.—Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite; in the collection of Dr. L. D. Welch, now deposited in Wilmington college.

Remarks.—*Phragmoceras wilmingtonense* is characterized by the cuneate outline of most of the upper part of the conch on lateral view, the small rise in elevation of the flattened upper side of the chamber in a dorsad direction, the straightness of the sutures, and the small curvature of the septa in a dorso-ventral direction. It differs from *Phragmoceras cuneiforme* in the more convex curvature of the upper part of the dorsal outline of the living chamber, in the small slope of the flattened upper surface of this chamber compared with the plane of the suture at its base, and in its relatively greater width, especially dorsally. The outline of this chamber as viewed from above is ovate, while in the other species named it is more subfusiform. A similar difference is noted in cross-sections of the phragmacone.

Bowling Green Specimen.—A specimen similar to the type of *Phragmoceras wilmingtonense* was found at Bowling Green (plate LI, figs. 2 A, B), 20 miles south of Toledo, Ohio, in the Cedarville dolomite. It differs chiefly in being slightly more compressed laterally, especially toward the ventral margin of the living chamber. The siphuncle appears to be larger and more distant from the ventral wall of the conch. Only the living chamber is preserved. Specimen No. 9441 A, Ohio State University.

TUBIFEROCERAS Hedström

Genotype: *Phragmoceras proboscideum* Hedstrom, Ueber die Gattung Phragmoceras in der Obersilurformation Gotlands, pp. 8, 11, pl. 1, figs. 1–10 (1917); Foerste, Jour. Sci. Lab. Denison Univ., 21, 352, pl. 48, figs. 2 A-C (1926).

Conch short, erect, cuneate in outline on lateral view, the dorsal outline moderately or slightly convex, the ventral outline nearly straight or faintly concave along the upper part of the living chamber. Dorsal expansion of the aperture nearly circular, narrowing rather abruptly at its junction with the narrowly contracted part of the aperture. The dorsal side of the dorsal neck of the living chamber slopes abruptly backward. The inner part of the shell at the base of this neck is thickened into a transverse ridge extending prominently upward and forward into the general cavity enclosed by the living chamber.

The Swedish Gotlandian species upon which this genus was based are *Phragmoceras proboscideum*, *Phragmoceras prominens* and *Phragmoceras prominens minus*. The American species *Trimeroceras gilberti* is closely related, and *Phragmoceras labiatum* and *Phragmoceras lineare* appear to be similar.

61. **Tubiferoceras gilberti** (Kindle and Breger)

Plate LX, fig. 2

Trimeroceras gilberti Kindle and Breger, 28th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 475, pl. 15, fig. 1 (1904).

Tubiferoceras gilberti Foerste, Jour. Sci. Lab. Denison Univ., 21, 352, pl. 48, figs. 2 A–C (1926).

Specimen consisting of a living chamber with 9 camerae still attached. The ventral outline of the phragmacone is straight or only faintly concave. The convex dorsal outline has a radius of curvature of 125 mm. along the phragmacone and the lower half of the living chamber. The height of the living chamber is 72 mm. at the dorsal end of the narrowly contracted part of the aperture. At the base of the specimen the dorsal and ventral outlines diverge from each other at an angle of 50 degrees, changing to about 25 or 30 degrees along the upper part of the phragmacone and the lower half of the living chamber. The lower margin of the collar supporting the dorsal expansion of the aperture is outlined by a groove which forms an angle of 135 degrees with the vertical dorsal outline of the living chamber. This groove locates a thickening of the interior of the shell so as to form an acute ridge extending diagonally inward and upward from the

dorsal and dorso-lateral sides of the collar for a distance of 4 or 5 mm. The dorsal outline of this collar slopes outward at about the same angle as the inward slope of the ridge at the base of its interior. The dorsal expansion of the aperture has a width of about 40 mm. The lateral outlines of the conch diverge at an angle of 30 degrees along the phragmacone and for 35 mm. above the base of the living chamber, the strong inward curvature of these sides beginning about 15 mm. farther up. A vertical section across the top of the living chamber in a lateral direction presents a moderately depressed semicircular outline.

The conch is compressed laterally. At the base of the living chamber, where the dorso-ventral diameter is 95 mm., the lateral diameter is estimated at 65 mm. The dorsal side of a cross-section of the conch is rather evenly convex, but its ventral part tends to be more or less distinctly angular, the ventro-lateral parts converging here at an angle of about 90 degrees. It is estimated that about 15 camerae occurred in a length equal to the dorso-ventral diameter of the conch at the top of the phragmacone. The sutures of the septa are almost directly transverse along the lower part of the phragmacone, but curve about 2 mm. downward along some of the septa along its upper part. The septa are moderately concave. The siphuncle is close to the ventral wall.

Occurrence.—Wabash, Indiana; in the Liston Creek limestone member of the upper Niagaran. Specimen No. 22954, Walker Museum, Chicago University.

62. **Tubiferoceras labiatum** (Whitefield)

Phragmoceras labiatum Whitfield, Geol. Surv. Wisconsin, 4,302, pl. 20, figs. 1, 2 (1877).

Living chamber apparently belonging to an erect conch, its ventral outline inclining moderately forward, and its dorsal outline almost vertical compared with the plane of the suture at its base. The upper part of its dorsal side, forming the dorsal neck, slopes abruptly backward, the lower margin of this neck being sharply defined in casts of the interior of the living chamber by a narrow groove, indicating a corresponding elevation on the inner

surface of the shell. The outline of the dorsal expansion of the aperture is ovate, with the pointed end directed backward. The anterior or ventral margin of this expansion is indented by the backward growth of that part of the shell which borders on the narrowly constricted part of the aperture.

Occurrence.—Ashford, Wisconsin; in the Waukesha dolomite. Specimen destroyed by fire.

63. **Tubiferoceras** (?) **lineare** (Newell)

Gomphoceras linearis Newell, Proc. Boston Soc. Nat. Hist., 23, 473–474, two text figures (1888).

Conch strongly flattened laterally, and considerably curved lengthwise, its dorsal outline being strongly convex and its ventral outline moderately concave. The upper part of the dorsal side of the living chamber slopes abruptly backward, forming a dorsal neck, whose lower margin, in casts of the interior of the chamber, is outlined by a narrow groove, corresponding to a ridge on the inner surface of the shell. The dorsal expansion of the aperture appears to have been short dorso-ventrally, and oval in outline. It appears to have narrowed rather gradually into the narrowly contracted part of the aperture. Apparently the original lateral compression of the conch was much accentuated by pressure after the death of the animal.

Occurrence.—Bridges quarry, Wabash, Indiana, in the Liston Creek limestone member of the upper Niagaran. Specimen no. 11175, Boston Soc. Nat. Hist.; holotype.

GOMPHOCERAS Sowerby

Genotype: *Orthoceras pyriforme* Sowerby, in Murchison's Silurian System, 620, pl. 8, fig. 19, upper figure under this number only; Blake, British Fossil Cephalopoda, 192, pl. 22, figs. 2, 2 A (1882); Foerste, Jour. Sci. Lab. Denison Univ., 21, 353, pl. 49, figs. 1 A, B; 2 A, B (1926).

Conch erect, with dorsal outline slightly more convex than the ventral one. Living chamber largest at midheight, rounding rather evenly toward the aperture. The ventral outline of this chamber curves strongly backward on approaching the hyponomic

sinus of the aperture as in typical gomphoceroids. However, the form of the dorsal expansion of the aperture is very much in doubt. Blake figures this dorsal expansion as elliptical with its major axis in a dorso-ventral direction. I have tried to follow him. It must be acknowledged, however, that there is very little basis for this interpretation. The fact is that the dorsal part of the aperture is not preserved and any attempt to determine its form from the nearest part of the shell remaining is likely to lead to error. It is significant that the only specimens of Lower Ludlow age showing a non-lobate dorsal expansion of the aperture are *Gomphoceras crater* Blake and *Gomphoceras cinctum* Blake, both relatively small species. Those specimens more nearly comparable in form and size with *Gomphoceras pyriforme*, such as *Gomphoceras obovatum* Blake and *Gomphoceras eta* Blake, have lobate dorsal expansions, the first with 4 dorsal lobes (Tetrameroceras), the second with 2 (Mandaloceras). From this it is evident that the genus *Gomphoceras* can not be regarded as well established until specimens of *Gomphoceras pyriforme* are found which definitely show the character of the dorsal expansion of their apertures. On the following pages the species provisionally referred to *Gomphoceras* are those in which this dorsal expansion is elliptical, circular, or ovate, but without lobation.

The Silurian formations of Gotland, in Sweden, contain several gomphoceroids in which the dorsal expansion of the aperture is non-lobate, its outline being approximately circular or elliptical, but none of these bear any resemblance to the genotype of *Gomphoceras*, and some of these evidently represent distinct generic types.

64. **Gomphoceras hector** (Billings)

Phragmoceras Hector Billings, Pal. Foss., Geol. Surv. Canada, 1, 163, text fig. 147, a, b (1865).

The dorsal outline of the conch is convex along its entire length, as far up as the margin of the dorsal lobe of the aperture, there being no reversal of curvature at the upper end of this dorsal outline as in typical *Phragmoceras*. Moreover, the spout-like prolongation of the shell at the hyponomic sinus does not

project strongly forward, and the upper part of the ventral outline curves inward on approaching the proximal end of this spout. These are features characteristic of *Gomphoceras*, used in its broader sense, rather than of *Phragmoceras*.

Occurrence.—New Hope, Ontario; in the Guelph member of the Niagaran. The type apparently has been lost.

65. **Gomphoceras ruedemanni** Sp. nov.

Plate XLV, fig. 2

Phragmoceras accola Ruedemann (in part) New York State Mus. Bull., no. 189, 79, pl. 26, fig. 3 (not figs. 1, 4, 5), 1916.

Aperture but very moderately constricted compared with typical *Phragmoceras* or *Gomphoceras*. Dorsal expansion forming three-fourths of the length of the aperture in a dorso-ventral direction, this expansion being broader than long. The narrowly constricted part of the aperture is contracted to a width of slightly less than one third of the dorsal expansion of this aperture, and its length is only about one-third of that of this expansion. The ventral end of the aperture, corresponding to the spout at the hyponomic sinus of *Phragmoceras* and *Gomphoceras* is only slightly broader than the narrowly constricted part of the aperture, and there is no evidence of the prolongation of this hyponomic sinus into a spout.

Possibly this specimen represents an early stage of development of the constriction of an aperture which later more nearly resembled that of *Phragmoceras hector* Billings, which here is referred to *Gomphoceras*.

Occurrence.—Schooley farm, Crane Corners, in the town of Litchfield, Herkimer county, New York; in the Bertie member of the Upper Silurian. New York State Museum, Albany, New York. Specimen No. 12450–5.

66. **Gomphoceras osculum** Ruedemann

Gomphoceras osculum Ruedemann, New York State Museum Bull., no. 189, 76, pl. 27, figs. 10, 11 (1916).

Conch small, total length about 30 mm., the living chamber equalling about half the total length of the conch. The dorso-

ventral diameter of the living chamber is 16 mm., its length being about the same. The ventral outline of the conch is concave along the phragmacone and convex along the living chamber. The dorsal outline of the living chamber is convex along the entire length of the chamber, not reversing to concave on approaching the aperture.

Occurrence.—Morganville, New York, under the bridge; in the Cobleskill member of the Upper Silurian. New York State Museum. Specimen No. 12192.

67. **Gomphoceras** (?) **cameroni** Foerste and Savage

Phragmoceras cameroni Foerste and Savage, Jour. Sci. Lab. Denison Univ., 22, 96, pl. 17, figs. 1 A, B (1927).

Living chamber apparently erect, with the suture of the septum at its base rising moderately in a dorsad direction. There is no evidence of an outward curvature of the dorsal outline of the chamber a short distance below the margin of the aperture as in typical *Phragmoceras;* and the ventral outline of this chamber does not incline forward as in most species of that genus. The conch is only moderately compressed laterally. The dorsal expansion of the aperture is broadly rounded, and the remainder of the aperture does not appear as narrowly contracted nor as strongly prolonged in a dorso-ventral direction as might be expected in the genus named. Provisionally, therefore, this species is referred to *Gomphoceras,* a more definite reference demanding specimens with better preserved apertures.

Occurrence.—Great Slave lake, at the southern end of the west side of the North Arm of this Lake, in northern Canada; in Middle Silurian strata approximately equivalent to the Attawapiskat limestone member of the area southwest of Hudson Bay. Victoria Memorial Museum, Ottawa, Ontario, Canada.

68. **Gomphoceras** (?) **ortoni** Foerste

Gomphoceras ortoni Foerste, Geol. Surv. Ohio, 7, 533, pl. 33, figs. 8a, b; pl. 36, figs. 7a–c (1893).

Base of living chamber 31 mm. in diameter dorso-ventrally and 25 mm. laterally, contracting to corresponding diameters of 25

mm. and 21 mm. in a length of 17 mm.; at this level there is a faint constriction above which the rate of contraction of the chamber is slightly less. The constriction mentioned is a little more distinct dorsally than ventrally. The upper part of the living chamber is unknown, the details represented in the figures cited above being worked out of the matrix filling the interior of the chamber. There appears to be a trace of a hyponomic sinus similar in its downward extension to that of *Stenogomphoceras;* however, even this is uncertain. It will require the discovery of additional specimens before those already known can be referred definitely to *Gomphoceras* or to some other genus.

Occurrence.—Brown's quarry, 2 miles west of New Carlisle, Ohio, on the road to Tippecanoe; in the Brassfield member of the Lower Silurian.

Remarks.—The larger specimen, including both the living chamber and the phragmacone, represented by fig. 7c on pl. 36, cited above, belonging to Ohio State University, has been lost. In general form it resembled the conch of *Mandaloceras scrinium,* but it retained no part of the aperture.

STENOGOMPHOCERAS Gen. nov.

Genotype: *Stenogomphoceras chadwicki* Foerste.

Conch strongly compressed laterally, the sutures of the septa forming broad shallow lateral lobes and narrow dorsal and ventral saddles, the latter tending to be more narrowly rounded than the dorsal saddles. The siphuncle is located near the ventral wall of the conch. The living chamber is relatively tall, and usually is constricted more or less distinctly above mid-height by a broad shallow transverse groove which becomes indistinct ventrally. The aperture is gomphoceroid in outline. By far the greater part of this aperture is included within its dorsal lobe which is somewhat circular in outline, but slightly sinuate along its margin in well preserved specimens of the genotype. Five broad and very shallow sinuses may be detected. The unpaired sinus faces directly backward; the posterior pair faces dorso-laterally, and the anterior pair faces ventro-laterally and is distinctly smaller than the remaining sinuses. From this approximately circular

dorsal lobe of the aperture a narrowly constricted part with subparallel sides extends in a ventrad direction and terminates in a somewhat expanded lip at the hyponomic sinus. This sinus extends a considerable distance down the ventral outline of the living chamber, and only the lower margin of the lip usually is preserved, the remainder of the lip being broken off in freeing the specimen from the surrounding rock. The aperture is well preserved only in the genotype, but traces of similar structure are found occasionally also in specimens of the other species. Usually the apertures are not preserved, although living chambers are relatively common.

69. **Stenogomphoceras chadwicki** Sp. nov.

Plate LXI, figs. 2 A, B, C, D

Living chamber compressed laterally, contracting at a transverse groove 16 mm. above the base of the specimen, and again at the top of the chamber, about 2 mm. beneath the margin of the aperture laterally and dorsally. The lateral diameter at the base of the specimen is 22 mm., and the dorso-ventral diameter is 27 mm. At the transverse groove near mid-height the corresponding diameters are 19 mm. and 23 mm. At the contracted part 2 mm. beneath the aperture the lateral diameter is 17 mm., increasing slightly at the margin of the aperture. The base of the lip formed by the hyponomic sinus is 19 mm. above the ventral end of the suture of the septum at the base of the chamber. The highest part of the groove outlining the lateral margins of the narrowly contracted part of the aperture is 32 mm. above this suture. This contracted part slopes downward in a ventrad direction at an angle of 25 degrees with a horizontal plane. The dorsal expansion of the aperture has a width of 17.5 mm. laterally and a length of 16 mm. dorso-ventrally. Its posterior margin presents a faint lobe 9 mm. in width; the faint lateral lobes are 10.5 mm. in width, and apparently there is a faint antero-lateral lobe on each side of the aperture 5.5 mm. in width. This antero-lateral pair of lobes is known only in the type specimen. The transverse section of the chamber at its base is slightly more

narrowly rounded ventrally than dorsally. The suture of the septum curves distinctly downward laterally. In phragmacones assumed to belong to this species about 9 or 10 camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series of camerae counted. In two specimens the dorso-ventral apical angle equals 14 and 18 degrees respectively. In two other specimens, which may belong to some other species, this apical angle equals 27 and 28 degrees. It is not possible at present to determine definitely which phragmacones belong to the living chambers here used in defining the species. In all specimens the concavity of the septa in a lateral direction is slight, equalling about 2 mm.

Occurrence.—Port Byron, in northwestern Illinois; in the Port Byron dolomite, regarded as stratigraphically directly above the typical Racine. Holotype in the U. S. National Museum. Named in honor of Prof. G. H. Chadwick.

MANDALOCERAS Hyatt

Genotype: *Gomphoceras bohemicum* Barrande, Systeme Silurien du Centre de la Boheme, 2, 306, pl. 74 (1867); Hyatt, in Zittel-Eastman, Text-book of Paleontology, 612, figs. 1133 A, B (1913); Foerste, Jour. Sci. Lab. Denison Univ., 21, 359, pl. 48, figs. 5 A-C (1926).

Erect gomphoceroids in which the dorsal expansion is reduced to two relatively narrow and strongly divergent lobes. In the genotype the general form of the aperture is T-shaped. Among the British species described by Blake, this type of aperture is shown by *Gomphoceras aequale* and the specimen referred by him to *Gomphoceras amygdala* Barrande. Among American species *Gomphoceras wabashense* Newell has a similar type of aperture.

Related species having a Y-shaped aperture are represented among British species by *Gomphoceras eta* Blake and *Gomphoceras neglectum* Blake. Among American species *Gomphoceras scrinium* Hall, *Gomphoceras marcyae* Winchell and Marcy, *Gomphoceras subgracile* Billings, and *Gomphoceras parvulum* Whiteaves have a similar Y-shaped aperture.

A typical species of *Mandaloceras* with T-shaped aperture occurs in the Silurian of Gotland, in Sweden.

70. **Mandaloceras wabashense** (Newell)

Gomphoceras wabashensis Newell, Proc. Boston Soc. Nat. Hist., 23, 470, three text figs. (1888).

Living chamber similar to that of *Gomphoceras scrinium*, but taller, the dorsal and ventral outlines being less convergent toward the aperture. The chief difference, however, is with the form of the aperture, which is T-shaped rather than Y-shaped, the two dorsal lobes being at right angles to that part of the aperture which is parallel to the dorso-ventral plane of symmetry. In this respect the aperture resembles that of the type of *Mandaloceras*.

Occurrence.—Harley Brothers quarry, at Delphi, Indiana; in Huntingdon dolomite member of upper Niagaran; approximately Guelph. Specimens 11173, 11173a, 11174, and 11174a in the museum of the Boston Society of Natural History, of which 11174 is the holotype.

71. **Mandaloceras scrinium** (Hall)

Plate LXII, figs. 3 A, B, C

Gomphoceras scrinium Hall, 20th Rept. New York State Cab. Nat. Hist., 350, pl. 18, figs. 1–3 (1868, extras in 1865).

Living chamber 35 mm. in height, with a dorso-ventral diameter of 41 mm. and a lateral one of 39 mm. at its base, both diameters at 5 mm. above the suture at the base of the chamber. The vertical dorsal outline is slightly less convex than the lateral and ventral outlines. The outline of the aperture is Y-shaped. Between the two posterior lobes the upper part of the dorsal side of the shell arches upward and forward, forming a broadly rounded crest. The groove defining the base of the elevations of the shell supporting these posterior lobes rises along the outer edge of this crest but becomes faint on approaching its top. The spout formed by the hyponomic sinus is 22 mm. above the suture at the base of the chamber. The septum at its base has a concavity of 8 mm. The passage of the siphuncle through this septum is 4 mm. in diameter and its center is 5 mm. from the ventral wall of the conch. The uppermost camera, still attached to the living chamber, is 1 mm. in height. The dorsal side of the cham-

ber retains most of the shell, and the surface of the latter is marked rather obscurely by transverse lines, the stronger of which occur at a rate of 7 in a length of 15 mm.

Occurrence.—Bridgeport, Illinois, now a part of Chicago; in the Racine dolomite. Specimen no. 2114 in the American Museum of Natural History; holotype.

Remarks.—Compared with the published figure of *Gomphoceras marcyae* the living chamber of this species is shorter and more dumpy.

72. **Mandaloceras marcyae** (Winchell and Marcy)

Gomphoceras Marcyae Winchell and Marcy, Mem. Boston Soc. Nat. Hist., 1, 101, pl. 3, figs. 8a, b (not 8c), 1865.

It is customary to regard *Gomphoceras marcyae* as a synonym of *Gomphoceras scrinium* and the writer has no evidence to controvert this. It will require a closer study of the abundant available material from the Chicago area to come to some more definite conclusion. In the meantime it is desirable to note several features presented by the figures of the two specimens illustrated by Winchell. In figure 8b, cited above, the form of the aperture is T-shaped, rather than Y-shaped, and the dorsal outline of the aperture, between the two dorsal lobes is evenly convex, rather than concave as in the type of *Gomphoceras scrinium.* It is not difficult to understand how the more divergent lateral margins of such an aperture as that presented by *Gomphoceras scrinium* might, on further contraction, lead to the more angular form presented by *Gomphoceras marcyae,* but it is not so easy to believe that the concave posterior outline of the aperture of *Gomphoceras scrinium* would readily change into the convex posterior outline of *Gomphoceras marcyae,* although a change in the opposite direction is not altogether incredible.

In the case of figure 8a, cited above, the conch apparently is oriented so as to give a direct view of the right dorsal lobe of the aperture with the dorsal crest of the shell bordering on this aperture on the left side of the figure, thus throwing the narrowly contracted part of the aperture leading to the hyponomic sinus out of view on the right side. It then is noted that the living chamber

is taller than in *Gomphoceras scrinium*, and that the maximum diameter of this chamber is fully one-third of the height of the chamber above its base, thus presenting a very different outline from that of Hall's species.

Occurrence.—Chicago, Illinois; in the Racine dolomite. According to information received from the late Prof. Stuart Weller, there is a possibility that the original collection of Silurian species from the Chicago area studied by Winchell and Marcy is in the possession of the Chicago Academy of Science, in which case it may be possible to restudy the types of this species more in detail.

73. **Mandaloceras subgracile** (Billings)

Plate XLV, figs. 3A, B; plate XLVI, figs. 3A, B

Gomphoceras subgracile Billings, Geol. Surv. Canada, Rept. of Progress for 1853–56, published in 1857, p. 311.

Specimen 70 mm. long, consisting of the living chamber with 13 camerae still attached. The lower part of the ventral side of the phragmacone is slightly concave, changing to distinctly convex farther up. The radius of curvature of the gibbous part of the ventral outline is 70 mm. and that of the convex dorsal outline is 40 mm. The maximum dorso-ventral diameter of the conch is located at the base of the second camera beneath the living chamber and equals 37 mm., diminishing to 35mm. at the base of this chamber, and to 24 mm. at the proximal end of the spout at the hyponomic sinus. The conch evidently is compressed laterally, apparently in part owing to pressure after the death of the animal. In its present condition the maximum diameter at the base of the second camera beneath the living chamber is 31 mm., diminishing to 30 mm. at the base of this chamber and to 18 mm. at the base of the collar supporting the dorsal lobes of the aperture. In the undistorted specimen the lateral diameter probably was only slightly less than the dorso-ventral one.

The living chamber contracts rather rapidly from its base upward. The base of the collar supporting the left dorsal lobe is 20 mm. above the suture at the base of the chamber. The

base of the proximal end of the spout at the hyponomic sinus is 11 mm. above this suture. A shallow groove outlines the lower part of the collar supporting the dorsal lobe and the proximal part of the spout. The aperture is assumed to have presented an outline similar to that of *Gomphoceras scrinium*, though only a part is preserved.

The upper 6 camerae occupy a total length of 14 mm. The sutures of the septa are straight. The siphuncle is not exposed.

Occurrence.—This specimen bears the printed label "*Gomphoceras subgracile* (Billings). Port Daniel. Chaleur Group. Div. 1. Sir. W. E. L.," with the written addition of "L'Anse á la Gascon, 1843." It is numbered 3053 in Victoria Memorial Museum, at Ottawa, Canada. Anse aux Gascons is 5 miles east of Port Daniel.

Remarks.—*Gomphoceras subgracile* is characterized by the change of curvature of its ventral outline from concave along the lower part of the phragmacone to convex along its upper part. In this respect it differs from the American species *Gomphoceras scrinium*, *Gomphoceras wabashense*, and *Gomphoceras parvulum* in which the conchs are straight, instead of moderately curved.

74. **Mandaloceras parvulum** (Whiteaves)

Gomphoceras parvulum Whiteaves, Canadian Rec. Sci., 4, 298, pl. 3, figs. 5, 5a, 5b (1891); Pal. Foss., Geol. Surv. Canada, 3, pt. 4, 296, pl. 35, figs. 2, 2a, 2b (1906).

Similar to typical *Mandaloceras* in the erectness of the conch and in the constriction of the dorsal part of the aperture into two narrow lobes diverging strongly from each other. Differing from the genotype, *Gomphoceras bohemicum* Barrande, in the lateral compression of the conch and in the divergence of the two dorsal lobes at angles of approximately 120 degrees.

Occurrence.—Grand Rapids of the Saskatchewan, Manitoba; in the Niagaran. The type has been lost.

HEXAMEROCERAS Hyatt

Genotype: *Phragmoceras panderi* Barrande, Systeme Silurien du Centre de la Boheme, 2, 232, pl. 48 (1867); Foerste, Jour. Sci. Lab. Denison Univ., 21, 362, pl. 50, figs. 3 A-C (1926).

Conch only slightly curved, nearly erect, with a gomphoceroid structure. The dorsal expansion of the aperture has 6 divergent lobes. In the genotype the two anterior lobes are directed ventro-laterally; the two middle lobes are directed slightly toward the rear of a directly lateral course, and their tips extend farther outward than those of the anterior pair; the posterior pair is short, relatively close together, and is directed straight backward. In addition to the genotype only one other cephalopod with this type of aperture is known, namely *Pristeroceras timidum* Ruedemann, but in the latter species the narrowly contracted part of the aperture presents a zigzag course, which is the chief characteristic of Ruedemann's genus.

In most other species referred to *Hexameroceras* the three pairs of dorsal lobes become consecutively larger in passing from the anterior pair to the posterior one, and the posterior pair is directed laterally or dorso-laterally instead of dorsally. Among the American species this includes *Hexameroceras cacabiforme, H. delphicolum, H. hertzeri, H. microstoma,* and *H. septore.*

Four species of *Hexameroceras* occur in the Silurian of Gotland, in Sweden. In addition, there are two species with three distinct pairs of dorsal lobes and two additional incipient lobes, evidently leading to *Octameroceras.* Of *Tetrameroceras* there are 4 species.

75. **Hexameroceras cacabiforme** Newell

Hexameroceras cacabiformis Newell, Proc. Boston Soc. Nat. Hist., 23, 481, text figures (1888).

Living chamber low and broad, its upper surface flattened and its dorsal, ventral, and lateral sides nearly vertical along the lower part of the chamber. Compared with *Hexameroceras hertzeri,* the posterior lateral lobes of the aperture are straighter and their tips are directed dorso-laterally, instead of curving forward.

Occurrence.—Delphi, Indiana; in the Huntingdon dolomite member of the upper Niagaran, approximately Guelph. Specimens no. 11184 and 11185, in the Boston Soc. Nat. Hist., the former being the holotype.

76. **Hexameroceras delphicolum** Newell

Hexameroceras delphicolum Newell, Proc. Boston Soc. Nat. Hist., 23, 479, text figures (1888).

Compared with *Hexameroceras hertzeri*, the conch is more strongly curved at the base of the living chamber. This chamber enlarges at about the same rate as the phragmacone for about half its height before contracting strongly toward the aperture. The curvature of the sutures of the septa is more strongly sigmoid. The postero-lateral lobes of the aperture are straight and their tips do not curve forward as in the species named.

Occurrence.—Delphi, Indiana; in the Huntingdon dolomite. Specimen No. 11182, Boston Soc. Nat. Hist.; holotype.

77. **Hexameroceras hertzeri** (Hall and Whitfield)

Plate XLIX, figs. 1A, B; 2; 3A, B; 4A, B; 5A, B

Cyrtoceras Hertzeri Hall and Whitfield, Geol. Surv. Ohio Pal., 2, 150, pl. 8, figs. 7, 8 (1875).

Hexameroceras hertzeri Miller, North Amer. Geol. Pal., 696, generic reference (1892).

Compared with *Hexameroceras panderi* (Barrande), the genotype, this species is much more strongly curved lengthwise, especially along the upper part of the phragmacone and the lower part of the living chamber. The aperture, moreover, resembles that of *Octameroceras callistomoides* Foerste rather than that of the genotype of *Hexameroceras*, excepting that the number of dorsal lobes of the aperture is only 6 instead of 8. The dorso-lateral lobes, namely, are much longer than in *Hexameroceras panderi*, and their proximal parts extend outward dorso-ventrally, their distal ends curving distinctly forward. The living chamber is relatively low and converges strongly from its base to the aperture. The phragmacone expands rapidly, with a strongly concave ventral outline, the convexity of the dorsal outline increasing from moderately convex along the lower two-thirds of the phragmacone to strongly convex farther up.

Occurrence.—The type (plate XLIX, figs. 3 A, B) is from Cedarville, Ohio; in the Cedarville member of the Middle Silurian. Specimen No. 5887, Ohio State University; holotype.

Wilmington specimen.—One of the specimens of *Hexameroceras* found in the Moodie quarry (plate XLIX, figs. 5 A, B) in Wilmington, Ohio, is strongly compressed laterally. It is regarded as a specimen of *Hexameroceras hertzeri* which was compressed after the death of the animal.

78. **Hexameroceras microstoma** Ruedemann

Plate XLIX, fig. 6

Hexameroceras microstoma Ruedemann, New York State Museum Bull., no. 189, 79, pl. 27, figs. 2–9 (1916).

Conch relatively small and distinctly curved lengthwise, the ventral outline being concave along the phragmacone and convex along the living chamber. The dorso-ventral diameter of this chamber enlarges from 21 mm. at its base to 26 mm. at mid-height, its full height being 26 mm. at the dorsal end of the aperture. The dorsal expansion of the aperture is six-lobed. The anterior pair of lobes is relatively short and located near the center of the living chamber when viewed from above. The other four lobes are of nearly equal size, two being directed ventro-laterally and the other two dorso-laterally with a relatively narrow dorsal crest of the shell between them.

Occurrence.—Niagara Falls, New York, in the Lockport (Guelph) dolomite. New York State Museum, No. 12238.

79. **Hexameroceras septore** (Hall)

Plate LXII, figs. 2 A, B, C

Gomphoceras septoris Hall, 20th Rept. New York State Cab. Nat. Hist., 350, text figs. 9, 10 (1868).

Living chamber with a dorso-ventral diameter of 26.5 mm. and a lateral one of 24.5 mm. at its base. From this point all sides converge toward the top of the chamber, its highest point being located at the dorsal end of the narrowly contracted part of the aperture which is 21.5 mm. above the base of the chamber. The basal part of the spout at the hyponomic sinus is 12.5 mm. above this base. The upper outline of the narrowly contracted part of the aperture slopes downward at an angle of 30 degrees in a ven-

trad direction. The three pairs of dorsal lobes are successively longer on proceeding from front to rear, all of the lobes enlarging toward their distal ends. The posterior pair of dorsal lobes leaves the median part of the aperture in a dorso-lateral direction and then curves so as to assume a more directly lateral course at its ends. Between these posterior dorsal lobes the upper part of the dorsal wall of the chamber rises in the form of a broadly rounded crest which curves forward into the notch formed by the posterior outlines of these lobes.

Occurrence.—Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 12649, in Walker Museum, Chicago University: holotype.

Remarks.—This type was figured by Hall as having a distinct median dorsal lobe. This error was due to the outline left by a fracture resulting in the spalling off of a thin sliver of the specimen along the median part of the dorsal crest of the shell bordering on the aperture. This error is readily detected in the presence of other specimens of the same species. See Addendum, page 381.

OCTAMEROCERAS Hyatt

Genotype: *Octameroceras callistomoides* Foerste, same specimen as *Phragmoceras callistoma* Barrande, Systeme Silurien du Centre de la Boheme, 2, 234, pl. 67, figs. 3, 4, 7 (1867); Hyatt, in Zittel-Eastmann, Text-book of Paleontology, 612, (1913); Foerste, Jour. Sci. Lab. Denison Univ., 21, 363, pl. 50, figs. 4 A-C (1926).

Differing from the second group of species under *Hexameroceras* only in the presence of 8 instead of 6 dorsal lobes to the aperture. Only one American species, *Octameroceras walkeri*, is known.

80. Octameroceras walkeri Foerste and Savage

Octameroceras walkeri Foerste and Savage, Jour. Sci. Lab. Denison Univ., 22, 104, pl. 23, figs. 5 A, B (1927).

Compared with the genotype, *Octameroceras callistomoides* Foerste (*Phragmoceras callistoma* Barrande in part, in Systeme Silurien du Centre de la Boheme, pl. 67, figs. 3, 4, 7, 67 (1867)), the living chamber is relatively short, with its dorsal outline more

erect and its ventral outline more oblique. The dorsal expansion of the aperture is shorter dorso-ventrally, the posterior pair of lobes is longer, and the general outline of the dorsal expansion of the aperture is more triangular.

Occurrence.—From a loose boulder at the limestone rapids on the Severn river, southwest of Hudson Bay, in either the Ekwan or Attawapiskat member of the Middle Silurian. Specimen no. 327S, Royal Ontario Museum of Paleontology, Toronto, Ontario, Canada.

EOTRIMEROCERAS Foerste

Genotype: *Eotrimeroceras jupiterense* Foerste, in Twenhofel, Geology of Anticosti, Geol. Surv. Canada, Mem. no. 154, 319, 320, pl. 53, figs. 2–6; pl. 51, fig. 5 (1927).

Differing from typical *Trimeroceras* in the weak development of the posterior lobe compared with the two broad lateral lobes. The only American species is *Eotrimeroceras jupiterense*. A similar type of aperture occurs in *Gomphoceras corona* described by Blake from Wenlock limestone of England. These two specimens show how a trilobate form of dorsal expansion could originate from a bilobate form.

In the Silurian of Gotland, in Sweden, there is a single typical species of *Trimeroceras*. In addition there are three species which might be described as species of *Mandaloceras* in which the aperture is T-shaped, the two dorsal lobes diverging in directly opposite directions; however, the median part of the dorsal expansion curves more or less distinctly backward, as in *Eotrimeroceras*. In two of these specimens there are small swellings in that part of the narrowly contracted division of the aperture which is nearest the dorsal expansion of the aperture. These swellings may be regarded as incipient lobes, suggesting how *Pentameroceras* might have originated.

81. Eotrimeroceras jupiterense Foerste

Eotrimeroceras jupiterense Foerste in Twenhofel, Geology of Anticosti, Geol. Surv. Canada, Mem. no. 154, 320, pl. 53, figs. 2–6; pl. 51, fig. 5 (1927).

Conch fusiform, with the maximum diameter at or near the base of the living chamber. Conch erect, the dorsal side being slightly more convex than the ventral one. The dorsal expansion of the aperture is wider laterally than long dorso-ventrally. The median part of the dorsal outline of this expansion extends backward slightly over 1 mm. in the form of a relatively broad dorsal lobe. This suggests an incipient stage of development of an aperture which later might result in a form similar to that of typical *Trimeroceras*.

Occurrence.—Two miles east of Jupiter river, on the shore of Anticosti Island, Canada; in the Jupiter member of the Middle Silurian. Specimen No. 3877a, Peabody Museum, Yale University.

Pentameroceras Hyatt

Genotype: *Gomphoceras mirum* Barrande, Systeme Silurien du centre de la Boheme, 2, 319, pls. 82, 91 (1867); Foerste, Journ. Sci. Lab. Denison Univ., 356, pl. 50, figs. 6 A-C (1926).

Small erect conchs, with the ventral outline more convex than the dorsal one. Dorsal expansion of aperture with 5 lobes, namely two pairs of lateral lobes and a single posterior lobe directed straight back. This fifth lobe is distinctly shorter than the remainder. Several American species occur, but among these only one has been distinguished so far from the genotype, namely *Pentameroceras rarum* Parks.

In the Silurian of Gotland, in Sweden, there are 4 species of *Pentameroceras*. In one of these there are incipient lobes along the dorsal end of the narrowly contracted part of the aperture. This suggests how *Septameroceras* might originate from *Pentameroceras*.

82. Pentameroceras cf. mirum (Barrande)

Plate XLIX, Figs. 7 A, B.

Gomphoceras mirum Barrande, Systeme Silurien du Centre de la Boheme, pls. 82, 91 (1867); figures of type copied in Jour. Sci. Lab. Denison Univ., 21, pl. 50, figs. 6 A-C (1926).

Pentameroceras mirum Newell, Proc. Boston Soc. Nat. Hist., 23, 483 (1888).

Specimens similar to *Pentameroceras mirum* have been found in southwestern Ohio, northern Indiana, southeastern Wisconsin, and northwestern Illinois. It is not likely that the Bohemian species succeeded in migrating as far as the central states without recognizable changes, but no special attempt has been made as yet to discriminate the different forms.

Compared with the Barrande type, the Ohio specimen (plate XLIX, figs. 7 A, B) has a shorter body chamber and its dorsal outline is less erect. The conch appears to be compressed laterally rather than depressed dorso-ventrally. From Adams county, Ohio, a quarter of a mile north of the Bacon Flat school, two and a half miles northeast of Peebles; in the Peebles member of the Middle Silurian. This specimen is too poorly preserved to serve as a type. It is in the U. S. National Museum.

The specimens from Indiana were obtained at Delphi; in the Huntingdon dolomite member of the upper Niagaran, approximately Guelph. To Newell they resembled "minnie bullets." Six specimens, studied by him, are preserved in the Boston Soc. Nat. Hist., where they are numbered 11187.

The specimens from Wisconsin were found in the Racine, at Milwaukee and Wauwatosa.

The specimens from Illinois enlarge along the lower half of their living chambers both laterally and dorso-ventrally and they contract more abruptly toward the aperture. They were found at Port Byron, on the Mississippi river, and are numbered 22814 in Walker Museum, Chicago University.

83. **Pentameroceras rarum** Parks

Pentameroceras rarum Parks.—Trans. Royal Canadian Inst., 11, 78, pl. 3, fig. 6 (1915); Foerste, Jour. Sci. Lab. Denison Univ., 22, 102, pl. 23, figs. 7 A, B, C (1927).

Compared with the genotype, *Gomphoceras mirum* Barrande, the living chamber is relatively shorter, the 5-lobed dorsal expansion of the aperture is located a little farther back from the center of the conch, and the narrowly contracted part of the aper-

ture is relatively longer and straighter as viewed from the lateral side of the conch.

Occurrence.—Above the limestone rapids on the Severn River, southwest of Hudson Bay, Canada; in either the Ekwan or Attawapiskat limestone. Specimen no. 324S, Royal Ontario Museum of Paleontology; Toronto, Ontario, Canada.

ADDENDUM

After page proof for the above article was prepared, Hyatt's genotype of *Septameroceras* was received from Ottawa. In the opinion of the writer, it is an *Hexameroceras*. Since it was neither figured or described by either Billings or Hyatt, a brief description follows.

Hexameroceras inflatum Sp. nov.

Gomplioceras inflatum Billings, in Hyatt's Genera of Fossil Cephalopods, Proc. Boston Soc. Nat. Hist., 22, 278 (1883).

Specimen erect, 30 mm. long, most inflated at base of living chamber, with dorso-ventral diameter of 48 mm. Dorsal enlargement of aperture 6-lobed, and out-lined as in *Hexameroceras hertzeri*, but more centrally located on top of living chamber, resembling *Hexameroceras gratum* (Blake) in this respect.

Occurrence.—L'Anse a la Barbe, 3 miles east of Port Daniel; in the Middle Silurian, Chaleur group, Div. 1.

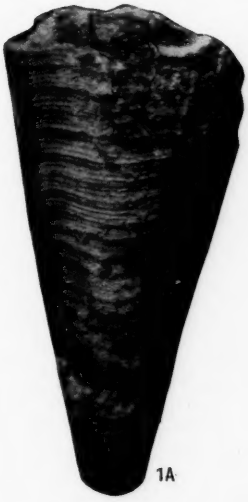
PLATE XLI

Fig. 1. *Ancistroceras undulatum* Boll. A, ventral view; B, lateral view with ventral outline on left. Schönwarling, Germany; erratic. Museum of Geological Survey of Prussia, Berlin.

Fig. 2. *Ancistroceras torelli* Remele. A, lateral view, with ventral outline on left; B, dorso-ventral section with ventral outline on right. From Baltic areas; from horizon C1, Orthoceras limestone. Museum of Natural History, Berlin, Germany.

Fig. 3. *Ancistroceras undulatum* Boll. A, ventral view; B, lateral view, with ventral outline on right. Gischkau, Germany; erratic. Museum of Geological Survey of Prussia, Berlin.

Fig. 4. *Ancistroceras undulatum* Boll; apical part of conch. A, lateral view of apical end, with impression left in matrix by the immediately succeeding part of conch; B, same specimen with succeeding part of conch in place; C, succeeding part of conch showing some of the transverse markings. Erratic; originally from Baltic areas. Museum of Geological Survey of Prussia, Berlin.


1A

1B

2A

3A

3B

2B

4A

4B

4C

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PLATE XLII

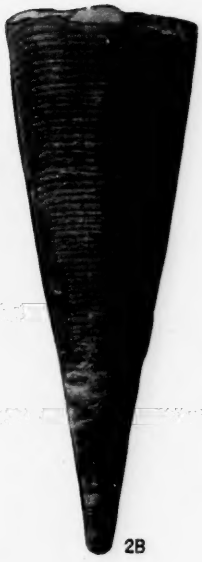
Fig. 1. *Rhynchorthoceras zaddachi* Remele. Ventral view of living chamber. Kunzendorf, Silesia, Germany; erratic. Museum of Geological Survey of Prussia, Berlin.

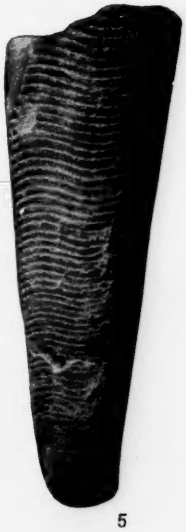
Fig. 2. *Rhynchorthoceras beyrichi* Remele. A, lateral view with ventral outline on left; B, dorsal view; C, dorso-ventral section through siphuncle, with ventral outline on left. Osselsk, Germany; erratic. Museum of Geological Survey of Prussia, Berlin.

Fig. 3. *Ancistroceras undulatum* Boll. Lateral section through siphuncle. Schönwarling, Germany; erratic. Museum of Geological Survey of Prussia, Berlin.

Fig. 4. *Ancistroceras undulatum* Boll. Dorso-ventral section through siphuncle. Schönwarling, Germany; erratic. Museum of Geological Survey of Prussia, Berlin.

Fig. 5. *Rhynchorthoceras zaddachi* Remele. Lateral view of phragmacone with ventral outline on left; living chamber, beginning immediately above the top of this phragmacone, omitted in figure. From limekiln near Lebbin, Germany. Museum of Geological Survey of Prussia.





1 2A 2B 2C 3 4 5

PLATE XLIII

Fig. 1. *Loxoceras kildarense* Foerste. A, lateral view with ventral outline on right; B, dorso-ventral section through siphuncle oriented in same direction, with outline of segment of siphuncle indicated in second camera from base of specimen. Kildare, Ireland; from Carboniferous limestone. Museum of Natural History, Berlin, Germany.

Fig. 2. *Palaeonautilus hospes* Remele. A, lateral view, with slight outward flare of shell at upper end of living chamber, but with the broadly flaring sides missing; B, ventral view, with the flaring lateral sides modelled in clay, but so oriented as to show but slightly in the figure. Lieseneff, bei Schivelbein, Germany; erratic. Museum of Geological Survey of Prussia, Berlin. See also figure 5 on plate XLIV.

Fig. 3. *Archiacoceras subventricosum* d'Archiac and de Verneuil. Dorso-ventral section through siphuncle with top of section 9 camerae beneath base of living chamber. From Schiessberg Bruch, near Sötenich, 15 miles southwest of Euskirchen, in the Eifel area of western Germany; Middle Devonian. Museum of Geological Survey of Prussia, Berlin. Only the ventral side of the section is presented, the entire dorso-ventral diameter at the top of the figured part being 95 mm.

1A

1B

2A

3

2B

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PLATE XLIV

Fig. 1. *Cyrtoceras depressum* Bronn. Dorso-ventral section through siphuncle of upper part of phragmacone. Pelm railroad station, a mile northeast of Gerolstein in the Eifel area of western Germany; Middle Devonian. Museum of the Geological Survey of Prussia, Germany.

Fig. 2. *Eifeloceras kayseri* Foerste. A, ventral view showing ventral saddles of sutures of septa; B, lateral view showing lateral lobes of these sutures; C, dorso-ventral section of siphuncle, showing only the septal necks; D, cross-section showing location of siphuncle. From the Eifel area of western Germany; Middle Devonian. Museum of Natural History, Berlin, Germany. The ventral outline is on the left in B, and on the right in C.

Fig. 3. *Cyrtoceras depressum* Bronn. Dorso-ventral section through siphuncle of middle part of phragmacone. From Eifel area of western Germany; Middle Devonian. Museum of Natural History, Berlin, Germany.

Fig. 4. *Palaeonautilus hospes* Remele. Lateral view, specimen retaining the ventral side of the flaring part of the aperture. Herzsprung, in the Uckermark, Germany; in the Upper Gray Orthoceras limestone. Museum of Geological Survey of Prussia, Berlin.

Fig. 5. *Palaeonautilus hospes* Remele. View of septum showing location of siphuncle in that part of specimen represented by figure 2A on plate XLIII which is nearest the aperture of the living chamber; also a part of the next smaller volution in which this siphuncle is not preserved.

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PLATE XLV

Fig. 1. *Gonioceras occidentale homerense* Foerste. Ventral view. Homer, La Salle county, Illinois; Platteville member of the Black River. Specimen no. 990, American Museum of Natural History.

Fig. 2. *Gomphoceras ruedemanni* Foerste. View of top of living chamber showing the aperture with the hyponomic sinus at its top. Crane Corners, in town of Litchfield, Herkimer county, New York; in the Bertie member of the Upper Silurian. Specimen 12450 in New York State Museum, Albany, New York.

Fig. 3. *Mandaloceras subgracile* (Billings). A, ventral view showing hyponomic sinus, specimen distorted; B, view of top of living chamber showing aperture, with hyponomic sinus at its top. See also figures 3A, B on plate XLVI. This type is distorted and preserves its aperture very poorly. The figures here presented show the general outline of the specimen well but the form of the aperture has been modelled in clay to show the writer's conception of the outlines of the latter. Distinct generically from *Hexameroceras inflatum* Foerste, described on page 581.

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PLATE XLVI

Fig. 1. *Gonioceras occidentale* Hall. Dorsal view. Platteville, Wisconsin; Platteville dolomite, Black River formation. Specimen no. 990; American Museum of Natural History.

Fig. 2. *Gonioceras kayi* Foerste. Dorsal view. Paint Creek township, Allamakee county, Iowa; in Guttenberg member of Decorah formation. Specimen No. 8022, State University of Iowa.

Fig. 3. *Mandaloceras subgracile* (Billings). A, lateral view, with hyponomic sinus of aperture on left; B, dorsal view, showing the two lateral lobes of the dorsal expansion of the aperture. In both views the outlines of the specimen are correctly given, but the aperture has been restored in clay in order to give the interpretation of the writer as to its original form. In the type itself this aperture is poorly preserved. Same specimen as that represented by figures 3A, B, on plate XLV.

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THREE STUDIES OF CEPHALOPODS

PLATE XLVII

Fig. 1. *Lambeoceras* cf. *lambi* (Whiteaves). Dorsal view of conch, the septa sloping downward from this side toward the opposite side. Stewartville, Minnesota; in the Stewartville dolomite, at the top of the Galena phase of the Trenton. Specimen no. 8293, University of Minnesota. Identified by Clarke with *Tripteroceras lambi* Whiteaves, but the structure of its siphuncle is in doubt.

Fig. 2. *Tripteroceras planodorsatum* (Whitfield). Dorsal view. Minneapolis, Minnesota; Platteville dolomite, Black River formation. Specimen no. 8299, University of Minnesota. Figured by Clarke on his plate LVII.

Fig. 3. *Tripteroceras oweni* Clarke. Dorsal view. Cannon Falls, Minnesota; Platteville dolomite; Black River formation. Specimen in collections of University of Minnesota; holotype.

Fig. 4. *Tripteroceras scofieldi* Foerste. Assumed to be the ventral view. Cannon Falls, Minnesota; Platteville dolomite, Black River formation. Same specimen as that identified by Clarke as *Tripteroceras planoconvexum* (Hall) on his plate LVI in volume 3 of the Geol. Surv. of Minnesota.

Fig. 5. *Diestoceras clarkei* Foerste. Lateral view, with ventral outline on left. St. Paul, Minnesota; Upper part of Prosser member of the Trenton. Specimen no. 5837, University of Minnesota. Same specimen as that figured by Clarke under *Poterioceras apertum*.

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THREE STUDIES OF CEPHALOPODS

PLATE XLVIII

Fig. 1. *Armenoceras saxosum* Foerste. Part of a siphuncle in the collections of the Geol. Surv. of Canada, in Victoria Memorial Museum, Ottawa, Canada. Stony Mountain, Manitoba, Canada; in the Stony Mountain member of the Richmond formation.

Fig. 2. *Cameroceras* sp. An endocone projecting from beneath a camerated part of the conch. Collection of W. H. Shideler.

Fig. 3. *Westonoceras* (?) *minnesotense* (Clarke). Lateral view with ventral outline on right. Lime City, Minnesota; from upper half of Prosser member of the Trenton. Specimen no. 258, University of Minnesota, figured by Clarke on plate LVIII of volume 3, Geol. Surv. Minnesota; holotype.

Fig. 4. *Westonoceras* (?) *minnesotense* (Clarke). Dorso-ventral section through the siphuncle, with ventral outline on right. Opposite half of same specimen as that used by Clarke for his figure 10 on page 799, of volume 3, Geol. Surv. of Minnesota.

Fig. 5. *Cyrtoceras lineatum* d'Archiac and de Verneuil. Dorso-ventral section through the siphuncle ten and a half camerae below the top of the phragmacone. At the upper part of this section the total dorso-ventral diameter of the conch is 67 mm. and the lateral one is 72 mm. Wachtberg, near Sötenich, in the Eifel area of western Germany. Middle Devonian. Geological Survey of Prussia, Berlin.

Fig. 6. *Tripteroceras* sp. (Hader). Ventral view. Hader, Minnesota; in upper part of Prosser member of Trenton. Specimen in collections of University of Minnesota. Opposite side of same specimen as that figured by Clarke on plate LVII of volume 3 of Geol. Surv. of Minnesota under *Tripteroceras planoconvexum*.

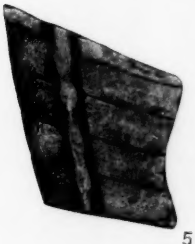
1

3

2

6

4



5

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THREE STUDIES OF CEPHALOPODS

PLATE XLIX

Fig. 1. *Hexameroceras hertzeri* (Hall and Whitfield). A, lateral view, with ventral outline on right; B, top of living chamber, showing form of aperture. Wilmington, Ohio; Moodie quarry; Cedarville dolomite; in U. S. National Museum, collected by Dr. George M. Austin.

Fig. 2. *Hexameroceras hertzeri* (Hall and Whitfield). Lateral view, with ventral outline on left. Wilmington, Ohio; Moodie quarry; Cedarville dolomite. In collection of Dr. L. D. Welch, deposited in Wilmington college.

Fig. 3. *Hexameroceras hertzeri* (Hall and Whitfield). A, lateral view, with ventral outline on left; B, ventral view, oriented so as to show the narrowly constricted part of the aperture and the hyponomic sinus. Cedarville, Ohio; Cedarville dolomite. Specimen no. 5887, Ohio State University; holotype.

Fig. 4. *Hexameroceras hertzeri* (Hall and Whitfield). A, lateral view of living chamber, with ventral outline on right; B, slightly oblique view of top of chamber, showing aperture. In collection of Dr. L. D. Welch, deposited in Wilmington college.

Fig. 5. *Hexameroceras hertzeri* (Hall and Whitfield). A, lateral view, with ventral outline on left; B, ventral view, showing narrowly contracted part of aperture and the hyponomic sinus. A laterally compressed specimen, regarded as compressed after the death of the animal. Wilmington, Ohio; Moodie quarry; Cedarville dolomite. In the collection of Dr. L. D. Welch, deposited in Wilmington college.

Fig. 6. *Hexameroceras microstoma* Ruedemann. Lateral view, with ventral outline on left. Niagara Falls, New York; in the Guelph part of the Lockport limestone. New York State Museum. Holotype. Same specimen as that figured by Ruedemann in New York State Museum Bull., no. 189, pl. 27, figs. 7, 8, 9 (1916).

Fig. 7. *Pentameroceras* cf. *mirum* (Barrande). A, lateral view of living chamber, with ventral outline on left; B, slightly oblique view of top of chamber showing poorly preserved outline of aperture. Northeast of Peebles, Ohio, two and a half miles, a quarter of a mile north of the Bacon Flat school; in the Peebles dolomite, or Guelph.

1A

1B

2

4A

3A

3B

4B

5A

5B

6

7A

7B

PLATE L

Fig. 1. *Phragmoceras wilmingtonense* Foerste. Lateral view, with ventral outline on right; spout restored. Wilmington, Ohio; Moodie quarry; Cedarville dolomite; holotype. Collection of Dr. L. D. Welch, deposited in Wilmington college.

Fig. 2. *Phragmoceras cuneiforme* Foerste. Lateral view, with ventral outline on left; spout restored. Wilmington, Ohio; Moodie quarry; Cedarville dolomite. Collection of Dr. L. D. Welch, Wilmington college

Fig. 3. *Phragmoceras cuneiforme* Foerste. Lateral view, with ventral outline on right; spout restored. Wilmington, Ohio; Moodie quarry; Cedarville dolomite. U. S. National Museum; collected by Dr. Geo. M. Austin.

Fig. 4. *Phragmoceras ellipticum* Hall and Whitfield. Lateral view, with ventral outline on right; top missing except at proximal end of spout formed by hyponomic sinus. Highland county, Ohio; in the Peebles or Guelph dolomite; associated with *Trimerella ohioensis*. Specimen no. 3413, Ohio State University; holotype.

Fig. 5. *Phragmoceras parvum* Hall and Whitfield. A, living chamber with ventral outline on left; B, lateral view, with ventral outline on right; the unseptated part of the phragmacone was carved out of the matrix by Welch. Wilmington, Ohio; Moodie quarry; Cedarville dolomite. Collection of Dr. L. D. Welch, Wilmington college. The holotype is illustrated on plate LV.

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THREE STUDIES OF CEPHALOPODS

PLATE LI

Fig. 1. *Phragmoceras hillsboroense* Foerste. A, lateral view of living chamber, with ventral outline on right; B, chamber viewed from above, showing aperture. Highland county, Ohio; more exact locality unknown; from the Peebles or Guelph dolomite. Specimen no. 3414, Ohio State University.

Fig. 2. *Phragmoceras wilmingtonense* Foerste. A, living chamber, viewed from above, showing aperture; B, lateral view of chamber, with ventral outline on left; end of spout restored. Bowling Green, Ohio; in the Guelph dolomite. Specimen no. 9441A, Ohio State University. See plate L for holotype.

Fig. 3. *Phragmoceras nestor* Hall. A, top of living chamber, showing aperture; B, lateral view, with ventral outline on left; spout restored. Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2116, in American Museum of Natural History; holotype.

1A

1B

2A

2B

3A

3B

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THREE STUDIES OF CEPHALOPODS

PLATE LII

Fig. 1. *Phragmoceras colliciare* Foerste. A, lateral view, with ventral outline on right; B, lateral view of another specimen, injured at the suture of the ninth septum beneath the living chamber, resulting in flexures of the sutures, gradually diminishing in strength. Wilmington, Ohio; Moodie quarry; in the Cedarville dolomite. Collection of Dr. L. D. Welch, deposited in Wilmington college. Paratypes.

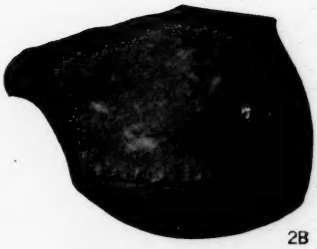
Fig. 2. *Phragmoceras colliciare* Foerste. A, lateral view, with ventral outline on left; B, living chamber, preserving the spout at the hyponomic sinus. Cedarville, Ohio, in the Cedarville dolomite. In the collection of the writer. Specimen A is the holotype.

Fig. 3. *Phragmoceras* cf. *colliciare* Foerste. A, lateral view of living chamber; B, top of chamber, showing the aperture. Bowling Green, Ohio; in the Guelph dolomite. Specimen no. 9442A, Ohio State University.

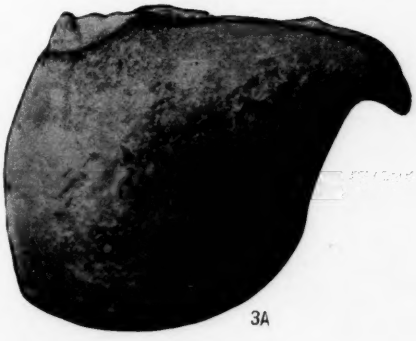
1A

2A

1B



2B



3A

3B

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THREE STUDIES OF CEPHALOPODS

PLATE LIII

Fig. 1. *Phragmoceras auroraense* Foerste. A, lateral view, with ventral outline on right; spout at *hyponomic sinus* restored. B, top of living chamber preserving narrowly contracted part of aperture, the extension of the latter into a spout restored. Rising Sun, northwestern Ohio; in the Guelph dolomite. Specimen no. 7302A, Ohio State University; holotype.

Fig. 2. *Phragmoceras auroraense* Foerste. A, top of living chamber, showing aperture; B, lateral view of same specimen, with ventral outline on left. Rising Sun, Ohio; in the Guelph dolomite. Specimen no. 7302B, Ohio State University; paratype.

Fig. 3. *Phragmoceras auroraense* Foerste. Outline of dorsal expansion of aperture, showing the trilobate character of its dorsal outline. Specimen no. 14809B, Ohio State University.

1A

1B

2A

3

2B

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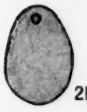
PLATE LIV

Fig. 1. *Phragmoceras canadense* Whiteaves. A, lateral view, with ventral outline on left, spoutlike projection at hyponomic sinus not preserved; B, top of living chamber of same specimen, with outline of part of aperture. Durham, Ontario; in the Guelph dolomite. Specimen no. 2920, Victoria Memorial Museum, Ottawa, Ontario, Canada.

Fig. 2. *Phragmoceras* sp. (Bacon Flat). A, lateral view, with spout and dorsal neck at top of living chamber restored; B, cross-section at base of living chamber. Adams county, Ohio; two and a half miles northeast of Peebles, and a quarter of a mile north of the Bacon Flat school. In the collection of the writer.

Fig. 3. *Phragmoceras procerum* Foerste. Lateral view of living chamber preserving the narrowly contracted part of the aperture; the remainder of the aperture absent or uncertain. Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2241, Museum of Comparative Zoology, Harvard University; paratype. See also plate LIX, fig. 1.

2A



2B

1B

1A

3

PLATE LV

Fig. 1. *Phragmoceras carmani* Foerste. Lateral view, with ventral outline on right; the upper dorsal part of the living chamber has been restored. Greene county, Ohio; probably from Cedarville; in the Cedarville dolomite. Specimen no. 10912, Ohio State University; holotype.

Fig. 2. *Phragmoceras parvum* Hall and Whitfield. Lateral view, with ventral outline on right. Cedarville, Ohio; in the Cedarville dolomite. Specimen no. 5889, Ohio State University; holotype. See also plate L, figs. 5 A, B.

1

2

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PLATE LVI

Fig. 1. *Phragmoceras angustum* (Newell). Lateral view, with ventral outline on right; part of spout restored. Wabash, Indiana; in the Liston Creek limestone member of the upper Niagaran. Specimen no. 22861, Chicago University. Plesiotype.

1

PLATE LVII

Fig. 1. *Phragmoceras raymondi* Foerste. Living chamber, retaining the narrowly contracted part of the aperture; also part of the shell, showing a banded type of ornamentation. Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2324, Museum of Comparative Zoology, Harvard University; paratype.

Fig. 2. *Phragmoceras* cf. *raymondi* Foerste. Part of a living chamber, supposed to belong to an immature specimen of *Phragmoceras raymondi*, before it had attained a size sufficiently large to show even a trace of contraction of its aperture. Surface of shell conspicuously banded. Specimen no. 2179, Museum of Comparative Zoology, Harvard University.

Fig. 3. *Phragmoceras altidorsatum* Foerste. Lateral view, with ventral outline on right. Cedarville, Ohio; in Cedarville dolomite. In collection of the writer.

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THREE STUDIES OF CEPHALOPODS

PLATE LVIII

Fig. 1. *Phragmoceras raymondi* Foerste. Living chamber, with ventral outline on right. Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2249B, Museum of Comparative Zoology, Harvard University; holotype.

Fig. 2. *Phragmoceras ontarioense* Foerste. A, lateral view, with ventral outline on right; B, top of living chamber, showing indentation of ventral side of dorsal expansion of the aperture. Hespeler, Ontario, Canada; in the Guelph dolomite. Specimen no. 2916, Victoria Memorial Museum, Ottawa, Ontario, Canada. Same specimen as *Phragmoceras parvum* Whiteaves, Pal. Foss., Geol. Surv. Canada, vol. 3, pt. 1, pl. 7, fig. 2 (1884).

Fig. 3. *Phragmoceras hespelerense* Foerste. Living chamber, lateral view, with ventral outline on left. Hespeler, Ontario, Canada; in the Guelph dolomite. Specimen no. 2919, Victoria Memorial Museum, Ottawa, Ontario, Canada. Same specimen as *Phragmoceras Nestor* var. Canadense Whiteaves, Pal. Foss., Geol. Surv. Canada, vol. 3, pt. 1, pl. 7, figs. 1a, 1b (not fig. 1), 1884. See also plate LX, fig. 3.

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PLATE LIX

Fig. 1. *Phragmoceras procerum* Foerste. Living chamber with camerae attached, lateral view, with ventral outline on left. Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2323, Museum of Comparative Zoology, Harvard University; holotype. See also plate LIV, fig. 3.

Fig. 2. *Phragmoceras* cf. *procerum* Foerste. Phragmacone, with ventral outline on right. Wauwatosa, Wisconsin; in the Racine dolomite. Specimen no. 2244, Museum of Comparative Zoology, Harvard University.

1

2

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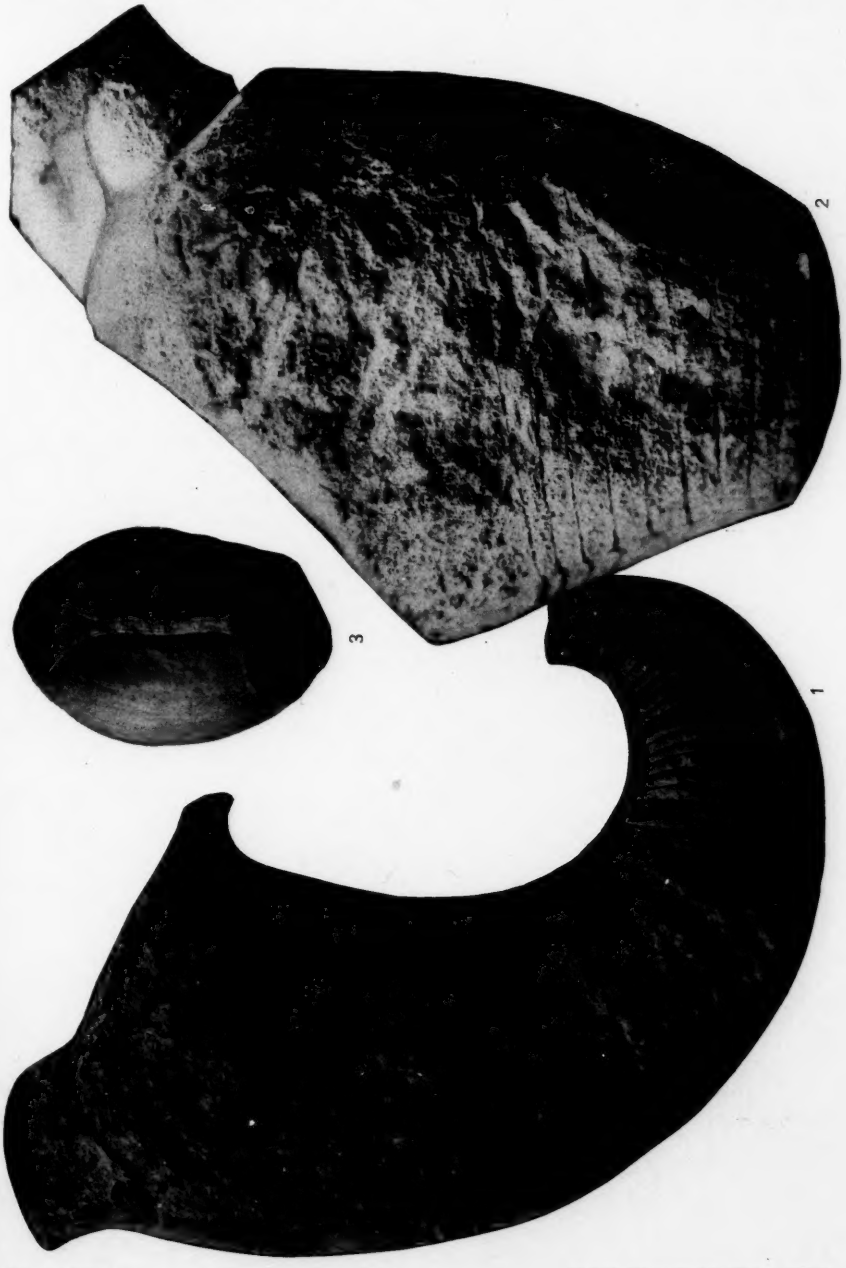
THREE STUDIES OF CEPHALOPODS

PLATE LX

Fig. 1. *Phragmoceras slocomi* Foerste. Lateral view of a nearly complete specimen, with ventral outline on right. Lannon, Wisconsin; presumably from the Waukesha dolomite. Specimen collected by A. W. Slocom, curator of Walker Museum, Chicago University.

Fig. 2. *Tubiferoceras gilberti* Kindle and Breger. Living chamber, with camerae attached; ventral outline on left. Specimen no. 22954, Walker Museum, University of Chicago; plesiotype. In the Liston Creek limestone member of the upper Niagaran.

Fig. 3. *Phragmoceras hespelerense* Foerste. Top of living chamber, showing aperture. Hespeler, Ontario, Canada; in the Guelph dolomite. Same specimen as that on plate LVIII, fig. 3.



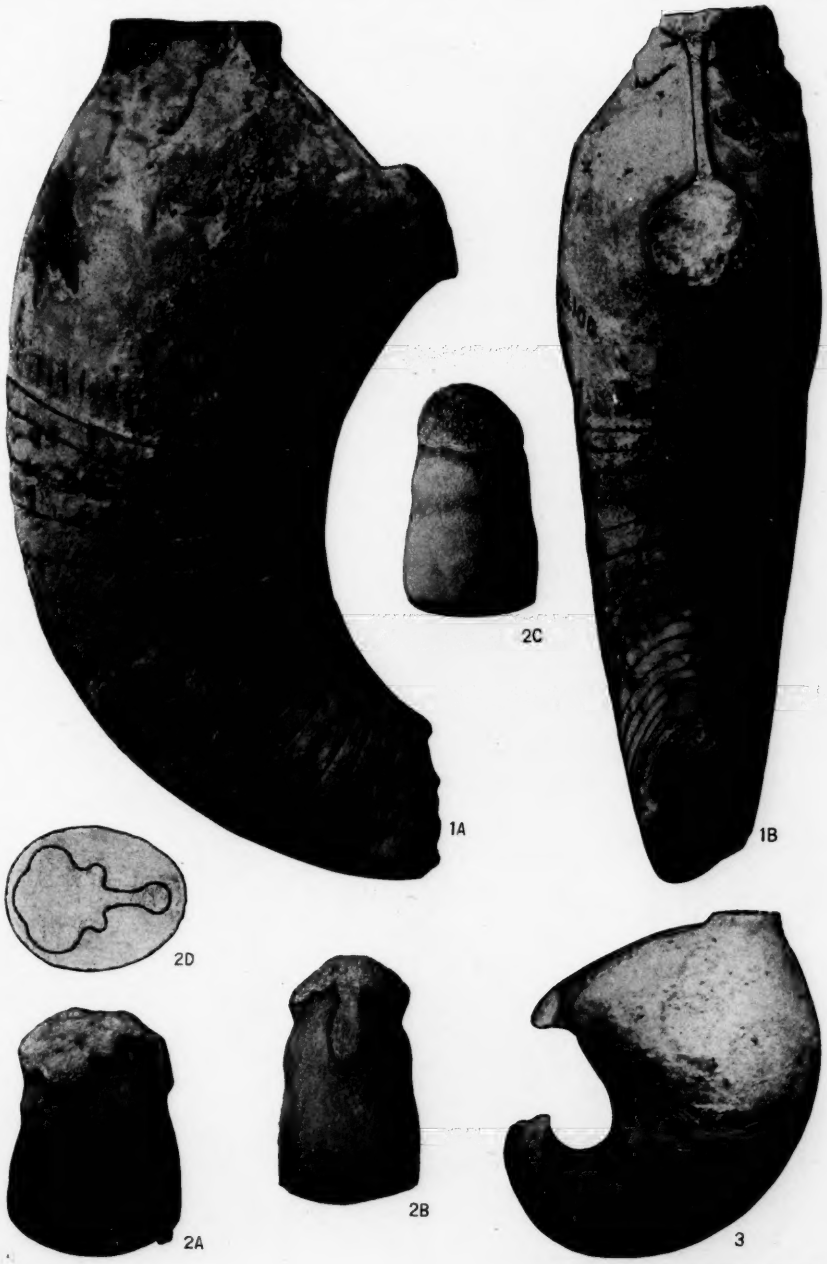
AUG. F. FOERSTE THREE STUDIES OF CEPHALOPODS

PLATE LXI

Fig. 1. *Phragmoceras byronense* Worthen. A, lateral view, with ventral outline on right; B, ventral view showing narrowly contracted part of aperture, the spout at the hyponomic sinus being broken off. Found erratic at Rock Island, originally probably from Port Byron, Illinois. Racine dolomite. Specimen no. 12100, Illinois State Museum, Springfield, Illinois.

Fig. 2. *Stenogomphoceras chadwicki* Foerste. A, lateral view of living chamber, with hyponomic sinus on right; B, ventral view with hyponomic sinus in front; C, dorsal view, showing faint lobation of aperture; D, Diagram of living chamber as viewed from above, showing form of aperture. Usually the lobation of the aperture is much weaker than that shown here. Port Byron, in northwestern Illinois.

Fig. 3. *Phragmoceras* sp. (Cedarville). Lateral view with ventral outline concave. Cedarville, Ohio; in the Cedarville dolomite. Specimen in collection of the writer.



AUG. F. FOERSTE

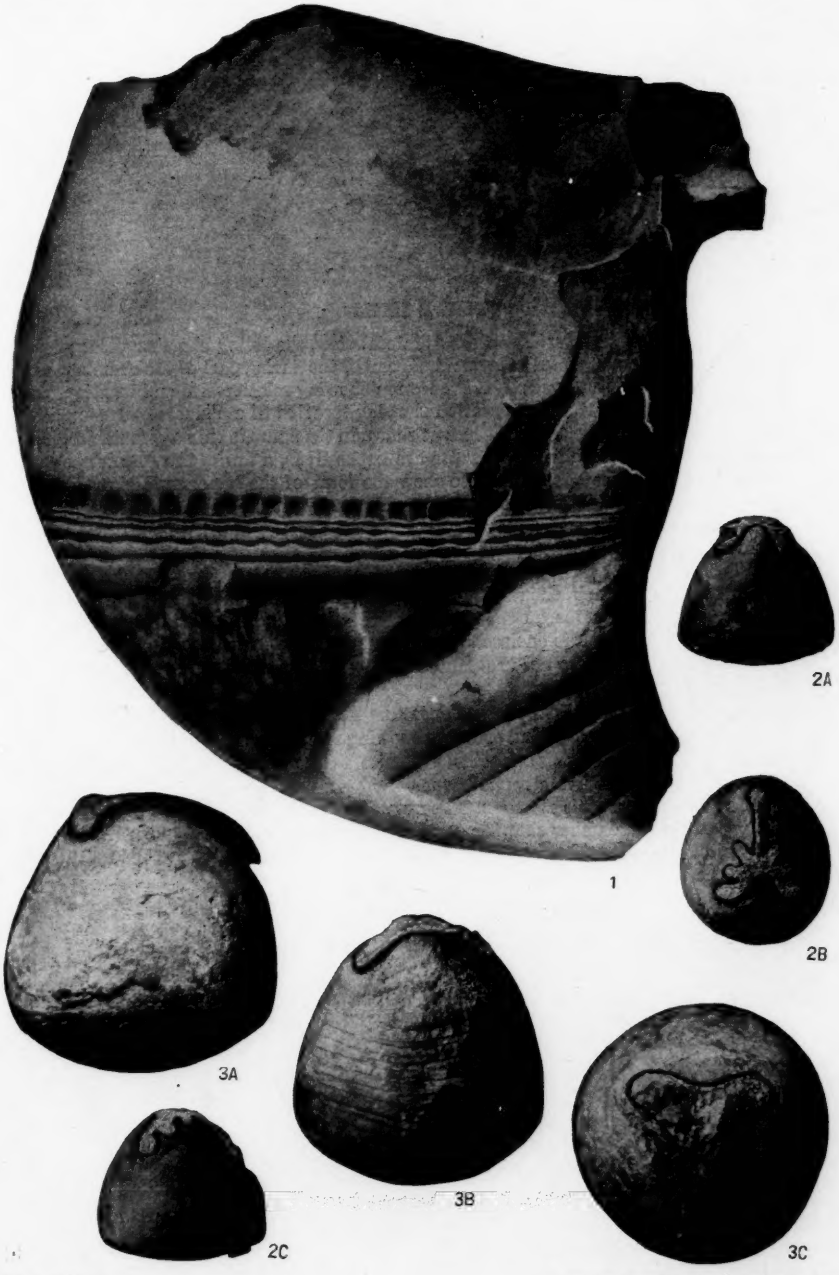
THREE STUDIES OF CEPHALOPODS

PLATE LXII

Fig. 1. *Phragmoceras accola* Ruedemann. Lateral view, with ventral outline on right. Schooley farm, Crane's Corners, town of Litchfield, Herkimer county, New York; in Bertie member of Upper Silurian. New York State Museum, Albany, New York. Selected holotype.

Fig. 2. *Hexameroceras septure* (Hall). A, dorsal view, showing crest of margin of aperture ascending between the two posterior lobes of this aperture; B, view of living chamber from above, showing the aperture with hyponomic sinus directed upward in the figure; C, lateral view of living chamber, with hyponomic sinus on right. Wauwatosa, Wisconsin; Racine dolomite. Specimen no. 12649, Walker Museum, Chicago University; holotype.

Fig. 3. *Mandaloceras scrinium* (Hall). A, lateral view of living chamber with ventral outline on right; B, dorsal view showing upward and inward curvature of shell along aperture between the two posterior lobes of the latter; C, top view of chamber, with the two posterior lobes of the aperture facing upward in the figure. Specimen no. 2114, American Museum of Natural History; holotype.



AUG. F. FOERSTE

THREE STUDIES OF CEPHALOPODS

PLATE LXIII

Fig. 1. *Trocholites faberi* Foerste. A, lateral view, the living chamber enlarging at its upper end, but only the proximal end of the flaring part of the chamber at the aperture is preserved; B, cross-section showing relative size and location of siphuncle; C, dorso-ventral section showing location of siphuncle and some of the septa; the course of these septa as shown in the figure is only approximate, owing to the way in which these septa are exposed; D, a few of the transverse striae on the surface of the shell, to show the form of the hyponomic sinus at earlier stages of growth. West Covington, Kentucky; at the top of the Trenton, below the *Dendrocrinus dyeri* layer and above the Bromley shale. Collection of Charles L. Faber; holotype.

Fig. 2. *Cameroceras* (?) *faberi* Foerste. Dorso-ventral section through the apical end of the conch, showing the preseptal cone and the introduction of successively larger camerae on the dorsal side of the siphuncle developing from this cone. The conch is enclosed in a stromatoporoid. Madison, Indiana; in the Hitz layer at the top of the Saluda member of the Richmond. Collection of Charles L. Faber; holotype.

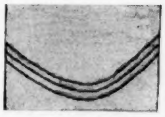
Fig. 3. *Phragmoceras chicagoense* Foerste. A, lateral view, with ventral outline on right; B, top of living chamber showing form of aperture as far as preserved. Chicago, Illinois; Racine dolomite. Specimen no. 22922, Walker Museum, Chicago University; holotype.

Fig. 4. *Phragmoceras chicagoense* Foerste. A, lateral view of living chamber; B, top of living chamber showing form of aperture. Chicago, Illinois; Racine dolomite. Specimen also numbered 22922, Walker Museum, Chicago University; paratype.

1A

1B

1C



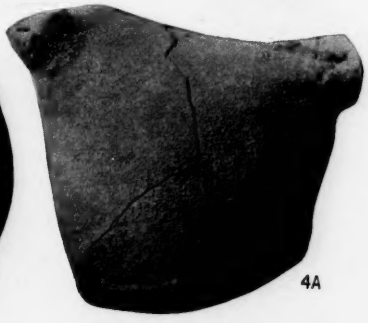
1D

3A

3B

2

4B



4A

A NEW GENUS OF MOSASAURS FROM MEXICO, AND NOTES ON THE PELVIC GIRDLE OF PLATECARPUS

M. G. MEHL

Received October 4, 1929; published January 22, 1930

Amphekepubis johnsoni Mehl, new gen. and sp.

The remains here described are of more than ordinary importance, not only because they are apparently characteristic of anew genus and species, but primarily because of their geographic occurrence. Hitherto mosasaurs have been reported from four widely separated regions; various localities in Europe, New Zealand, South America, and over a considerable area of the United States. Although this new find from northeastern Mexico is not far removed from some of the Gulf Coast localities of the United States it is a southern extension of the record and in that sense a connecting link between the distribution in South America and North America. It is unfortunate for stratigraphic purposes that the remains are not assignable to an established genus and species.

The specimen was found some years ago by Mr. Carlyle D. Johnson for whom the species is named. According to the recollections of Mr. Johnson the bones came from about forty miles east and a little north of Monterey in the state of Nuevo Leon, Mexico. Both locality and horizon are too indefinite to be of the greatest value. The matrix of the bones suggests certain parts of the San Felipe formation of the Upper Cretaceous, but this may be entirely misleading. It is likely that the remains are as young or younger than the San Felipe, however. At any rate, the find raises the question of age and its record should stimulate the search by petroleum geologists working in this part of Mexico for further evidence on this point.

THE MATERIAL

The remains consist of nine postsacral vertebrae, four of which are articulated; the right and left ilia; the left and part of the right pubes; the left ischium; the left femur; the right and left tibia; the left astragulus (tibiale) and part of the right; the left and right first metatarsal; a slender unit, likely the base of the fourth finger; and one complete phalanx from the first finger and parts of several other small phalanges.

It is clear from the condition of the remains that a careful search would reveal other pieces of the specimen. At the same time one is impressed with the completeness of the collection in the light of the fact that it includes "all that could be crowded into an already over-full suit-case, the only baggage carried in a hasty trip across country," as Mr. Johnson stated in making the gift. The specimen is recorded in the University of Missouri collections as No. 509 V. P.

All of the units were encased in a refractory matrix of concretionery clay considerably harder than the bone. Much credit is due Russel Farmer, a student in the University of Missouri, for his patience and skill in preparing the specimen for study.

Some of the bones are crushed, but the crushed units serve to emphasize the perfection of the other bones, most of which are essentially free from distortion.

THE VERTEBRAE

All of the vertebrae of the collection are postsacral. Of these the four anterior centra are articulated, and a fifth, the next unit posteriorly but one or possibly two, are pygals. The other four vertebrae of the collection are crushed and offer little information of value. One of them probably followed the last pygal and seems to have been chevron-bearing. The other three are small and from considerably further back in the tail. All of the vertebrae lack the arch. Of the pygals the second of the preserved series, probably the second or third of the original member, is typical of the group and remarkably well preserved. The following description is based on this unit.

THE PYGALS

The pygal vertebrae are moderately procoelous. The articular faces are essentially circular in outline with a diameter of about 65 mm. The body is markedly constricted immediately in front of the posterior face and is somewhat flattened on the ventral side. The length of the centrum is 73 mm. The transverse process projects from about mid-height of the centrum and

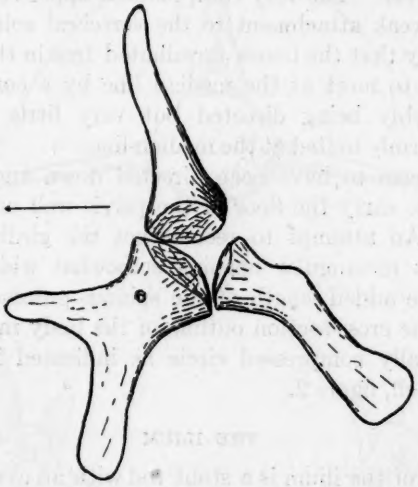


FIG. 1. LEFT LATERAL VIEW OF PELVIC BONES OF *Amphekepubis johnsoni* MEHL, × ¼

The arrow points anteriorly

is directed almost horizontally out and very slightly back so that its tip reaches the level of the posterior face of the centrum. The process is flattened throughout its length and at its tip is very thin and pointed. The base of the process measures 40 mm. antero-posteriorly. The anterior edge is confluent with the anterior face of the centrum. The processes are about 115 mm. long, a pair measuring 275 mm. from tip to tip.

THE PELVIC GIRDLE

The bones of the left side of the pelvic girdle are essentially complete and show very little evidence of distortion. The artic-

ular surfaces of these bones are particularly well preserved and are entirely lacking in the pitting characteristic of most mosasaurs, thus indicating a less amount of cartilage in the pelvis makeup.

Apparently ilium, ischium, and pubis were closely united to form a deeply cupped acetabulum. This is further evidenced by the well rounded and "finished" head of the femur. This suggested strength of the pelvic girdle is not borne out in other details, however. The very thin, pointed upper end of the ilium indicates a weak attachment to the vertebral column and even the possibility that the bones terminated free in the flesh. The pubes failed to meet at the median line by a considerable distance, probably being directed but very little inward. The ischia were firmly united at the median line.

The ilia seem to have been directed down and considerably back so as to carry the floor of the pelvis well under the pygal vertebrae. An attempt to reconstruct the girdle results in a more or less rectangular opening somewhat wider than deep. However, the added length of the spinous process of the vertebrae gives the cross-section outline of the body in the pelvic region a laterally compressed circle as indicated in the accompanying sketch, figure 2.

THE ILIUM

The shaft of the ilium is a stout rod with an average diameter of 20 mm. The upper end is spatulate, thin and pointed. This is in a small part due to crushing, but the chief result of the deformation seems to be a sinuosity of the bone as viewed posteriorly, instead of the normal, slightly incurved upper end. The lower end of the bone is greatly expanded in all directions. The pubic and ischial facets are long (antero-posteriorly) and narrow, almost at right angles to each other, and sharply set off from the acetabular surface. This is roughly circular in outline, nearly 40 mm. in diameter, markedly concave, and directed more out than down. The total length of the ilium is 155 mm.

THE PUBIS

The pubis is flattened throughout except at the greatly expanded acetabular end. The ischial and ilial articulation facets

are not sharply set off from each other nor from the acetabular surface of the bone. Apparently the pubis forms as large a proportion of the complete acetabular surface as does the ilium and considerably more than the ischium. The acetabular face is

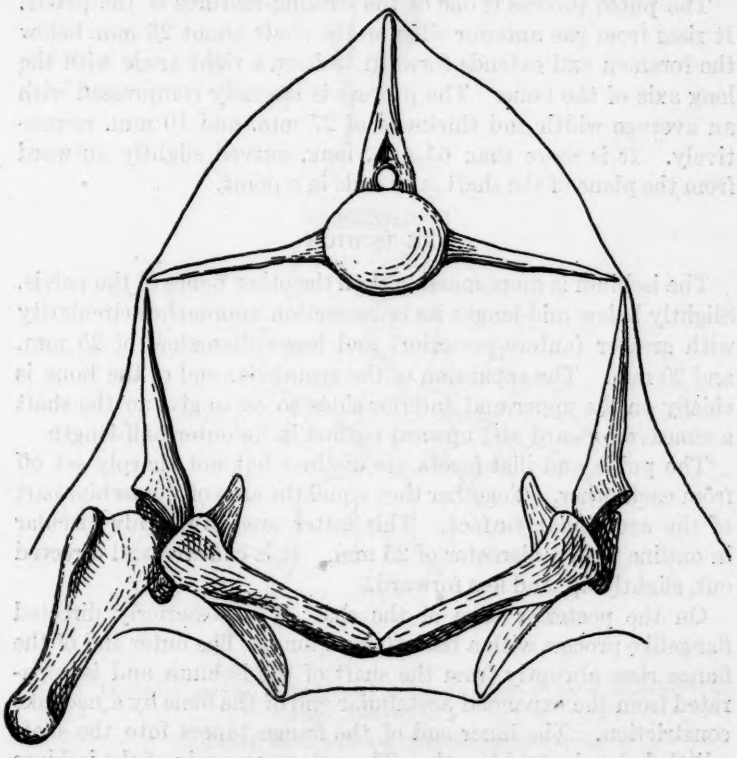


FIG. 2. DIAGRAMMATIC CROSS-SECTION IMMEDIATELY BACK OF PELVIS OF *Amphekepubis johnsoni* MEHL, × ½

directed outward. The pubis is sharply restricted antero-posteriorly below its upper end from a width of 67 mm. to 42 mm. at the level of the foramen. This opening is 27 mm. below the upper acetabular margin. From the constriction below the head the

pubis curves sharply back. The shaft is 27 mm. wide and 14 mm. thick with a slightly less sharply rounded posterior margin than anterior. The bone is 110 mm. long and terminates below in a spatulate point. Viewed from the posterior it is nearly straight.

The pubic process is one of the striking features of the pelvis. It rises from the anterior edge of the shaft about 25 mm. below the foramen and extends forward to form a right angle with the long axis of the bone. The process is laterally compressed with an average width and thickness of 27 mm. and 10 mm. respectively. It is more than 65 mm. long, curved slightly outward from the plane of the shaft, and ends in a point.

THE ISCHIUM

The ischium is more massive than the other bones of the pelvis. Slightly below mid-length its cross-section approaches circularity with greater (antero-posterior) and lesser diameters of 25 mm. and 20 mm. The expansion of the acetabular end of the bone is chiefly on the upper and anterior sides so as to give to the shaft a concave forward and upward outline in its outer half-length.

The pubic and ilial facets are distinct but not sharply set off from each other. Together they equal the area of the ischial part of the acetabular surface. This latter area is roughly circular in outline with a diameter of 25 mm. It is concave and directed out, slightly up, and less forward.

On the posterior edge of the shaft is a posteriorly directed flangelike process with a base 60 mm. long. The outer end of the flange rises abruptly from the shaft of the ischium and is separated from the expanded acetabular end of the bone by a necklike constriction. The inner end of the flange tapers into the shaft a little below its mid-length. The anterior margin of the ischium is straight in its lower half and has a broadly rounded edge. The full thickness of the anterior side is retained to the lower end where it is slightly increased. Although the posterior side of the symphyseal end is expanded into a thin edge there is little doubt but that the inner-anterior corners of the ischia met in a firm union. The total length of the ischium is 165 mm.

THE POSTERIOR LIMB

Judging from the parts of the left posterior limb that are preserved there was less cartilage involved than is the rule among

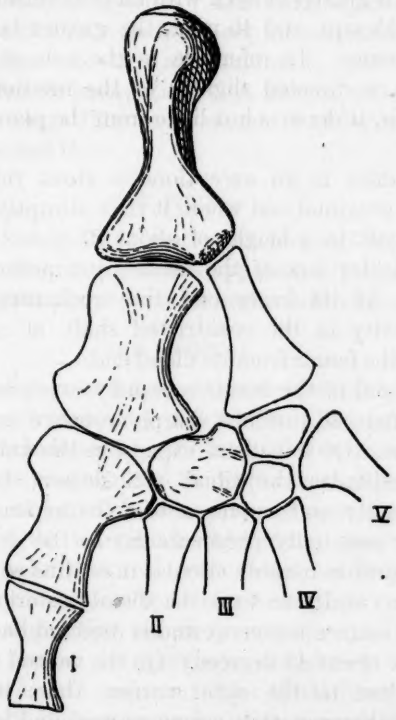


FIG. 3. DIAGRAM OF THE LEFT HIND PADDLE OF *Amphekepubis johnsoni* MEHL, FROM ABOVE, × ½
Unshaded units indicate probable arrangement

mosasaurs. The articular faces of the bones are sharply outlined and smooth. The limb is comparatively delicate in build with the bones of the upper ranges more elongate than usual, a feature particularly noticeable in the femur.

THE FEMUR

The femur is remarkably slender for that of a mosasaur. It is 160 mm. long and very greatly constricted a little below mid-

length. Here it has an approximately circular cross-section with a diameter of slightly more than 30 mm. Above the constriction the bone expands regularly on all sides to the head. The articular face here is greatly convex with an oval outline the diameters of which are 58 mm. and 46 mm., the greater being the antero-posterior diameter. In reference to the axis of the femur the articular face is directed slightly to the inferior and posterior sides. That is, it departs but little from the plane perpendicular to the axis.

The trochanter is an exceptionally stout ridge sharply recurved at its proximal end where it rises abruptly from the tibial side of the shaft to a height of about 27 mm. It is separated from the articular face of the femur by a pronounced necklike constriction. At its lower end the trochanter broadens and loses its identity in the constricted shaft at about one-third the length of the femur from its distal end.

The distal end of the femur is rapidly expanded laterally to a width of 87 mm. to produce sharply concave anterior and posterior margins. Of this distal expansion the anterior 70 mm. of the face constitutes the tibial articulation, broadly concave antero-posteriorly and convex across the expansion. This face is in a plane essentially perpendicular to the shaft of the bone. The fibular facet is roughly circular in outline with a diameter of about 25 mm. and truncates the distal-posterior corner of the femur. The surface is convex and is directed back from the axis at an angle of about 45 degrees. On the ventral side of the distal expansion, close to the outer corner, there is a pronounced rounded protuberance that seems normal and is probably characteristic (plate LXVII, fig. 1).

THE TIBIA

The tibia is 115 mm. long and at its mid-length constriction is 55 mm. wide. Both the proximal and distal ends are thickened and much laterally expanded. The inner margin is broadly rounded to a thickness of 22 mm. and in outline is broadly concave. The entire outer margin is thin and is much more sharply concave in outline than the inner margin.

The proximal face is concave across the expansion and essentially straight antero-posteriorly. It is 65 mm. long and 40 mm. wide and directed slightly outward from the axis of the bone. The distal expansion is 110 mm. The inner 40 mm. of the expansion is occupied by a concave facet for articulation with the astragalus. Adjacent to this articulation is that for the first metatarsal. This face is essentially flat, 28 mm. wide at the inner end and 50 mm. long. The outer corner of the distal expansion of the tibia is free and thin.

THE FIBULA

No part of either fibula is preserved, but the articular facets on the femur for this bone and the apparent arrangement of the tarsal bones suggests proportions as indicated in figure 3.

THE TARSUS

The only units of the tarsus preserved are a perfect left astragalus and part of the corresponding right unit. The left bone suggests other units as indicated by the unshaded outlines of figure 3.

The astragalus is roughly oval in outline with diameters of 63 mm. and 51 mm., the greater being transverse to the axis of the limb. All parts of the margin are thicker than the central part of the bone, the outer-proximal corner conspicuously so with a thickness of 23 mm. Except for a short length of rounded margin, a neck-like constriction on the proximal edge between the tibial and fibular facets, the margin is completely occupied by seven distinct articular surfaces. The tibial facet is convex, oval in outline with antero-posterior diameter of 38 mm. and cross diameter of 20 mm. The fibular facet is about 13 mm. in diameter. A facet, apparently for articulation with a fairly large calcaneum, parallells the axis of the limb on the posterior side of the astragalus. The inner-distal corner of the bone is truncated by an articulation for a third tarsal of large size. A facet on the distal margin, together with one on the third tarsal, forms an articulation for the third metatarsal. The facet on the distal-outer corner of the astragalus, with a much smaller facet on the inner-proximal edge of the first metatarsal, forms the

articulation for the second metatarsal. Between this last facet of the astragalus and that for the tibia is a truncation, about 17 mm. in diameter, that articulates with the inner-proximal corner of the first metatarsal.

THE METATARSALS

Of the metatarsals the first and one other, probably the fourth, are preserved. The first is somewhat thickened and much laterally expanded at the proximal end. It is still more thickened but less expanded at the distal end. The length is 90 mm. and the proximal, the mid-length, and distal widths are 75 mm., 37 mm., and 51 mm. respectively. Both inner and outer margins are sharply concave in outline. The outer margin is very thin, but the inner margin is thick and rounded. At the proximal end there are three more or less distinct facets for the tibial and astragalar articulations and a much lesser facet that articulates with the outer-proximal edge of the second metatarsal. The distal facet is concave and occupies the entire distal end.

Another unit, probably the fourth metatarsal, is exceptionally slender. It is 96 mm. long with diameters at the proximal and distal ends of about 20 mm. and a shaft 7 mm. wide and 12 mm. thick at mid-length.

THE PHALANGES

A single phalanx, the base of the first finger, is complete. In outline the lateral margins are sharply concave. The inner border is thick and rounded; the outer border very thin. The proximal and distal ends are thickened and have concave articular faces. The length of the bone is 80 mm. and the mid-length width is 20 mm. The proximal and distal widths are 52 mm. and 37 mm. respectively.

RELATIONSHIPS

The recurved, slender, unopposed pubes with remarkably developed anterior process; the stout, non-spatulate ischia; and the comparatively slender femora of the form here described offer a combination of characteristics sufficiently distinctive in

the opinion of the writer to demand recognition of generic rank. The genus *Amphekepubis* is therefore proposed to accomodate these features and *A. johnsoni*, based on the detailed description of the remains here described, is designated as the type species.

The remains are not sufficiently representative of the entire skeleton to permit a satisfactory comparison of *Amphekepubis* with even the better known mosasaur genera, but certain differences can be pointed out with assurance. The long, slender pubic process of the present form at once sets it off from genera like *Tylosaurus*, in which there is an entire absence of pubic process; and from the group of which *Platecarpus* is typical in which the process is a plate-like flange close to or a part of the acetabular expansion. A more intimate relationship between *Amphekepubis* and *Clidastes* is suggested by the spatulate or rod-like development of the pubic process of the latter, but in this group there is no form in which the development of the process is of such an extent as to suggest a "forked pubis" as it does in the form here described. In further contrast with *Amphekepubis*, *Clidastes* has an antero-posterior expansion of the symphyseal end of both pubis and ischium and the pubes are at least weakly united at the symphysis.

THE PELVIC GIRDLE OF *Platecarpus* COPE

There is no other group of extinct reptiles represented by such an abundance of material as the mosasaurs. It is also true that there are few other groups for which a complete revision would be more welcome. Many mosasaur genera have been proposed, most of them with several species, but many of the species have been described from very fragmentary remains and only a very few of the genera are represented by even fairly complete skeletons. As a consequence there is certainly a considerable duplication of specific and generic names.

In addition to the confusion that has arisen through the possibility of naming several species or genera from different parts of the same form, two other factors have contributed. Often times proportions of bones, clearly the result of post-burial deformation, have been described as characteristic. This is particularly

true of the mosasaur remains from the Kansas chalk beds. Quite aside from these "pseudo-variations" there is much evidence of real variation of individuals within the species. In this connection it seems quite likely that the amount of cartilage, particularly in the pelvis and the articular ends of the limb bones varied considerably with age and resulted in marked differences in the shapes of the bony parts preserved.

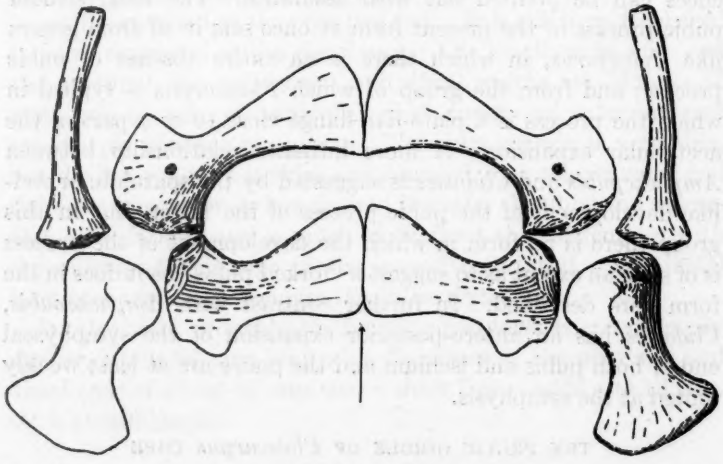


FIG. 4. PELVIC BONES OF *Platecarpus* (*Holosaurus*) *abruptus* MARSH, VIEWED FROM ABOVE, (EXCEPT ILIA), × ½
The arrow points anteriorly

In view of the fact that in the three decades following Williston's partial revision of Mosasauria[1] little has been done to clear the field, additional genera and species, although inevitable, are of doubtful value. They are justified, perhaps, in that they make for ready reference to additional details and in this way will ultimately aid in the revision of the group. It would seem that among the most valuable contributions is the recognition of described species and the addition of further details concerning them.

[1] S. W. Williston, Mosasaurs. Univ. Kans. Geol. Surv., 4 (pt. 1.), 83-221 (1898).

Among the mosasaur remains in the University of Missouri collections is a complete pelvis which, although apparently not representing a new species, is exceptional in that distortion through post-burial pressure has modified the proportions of the

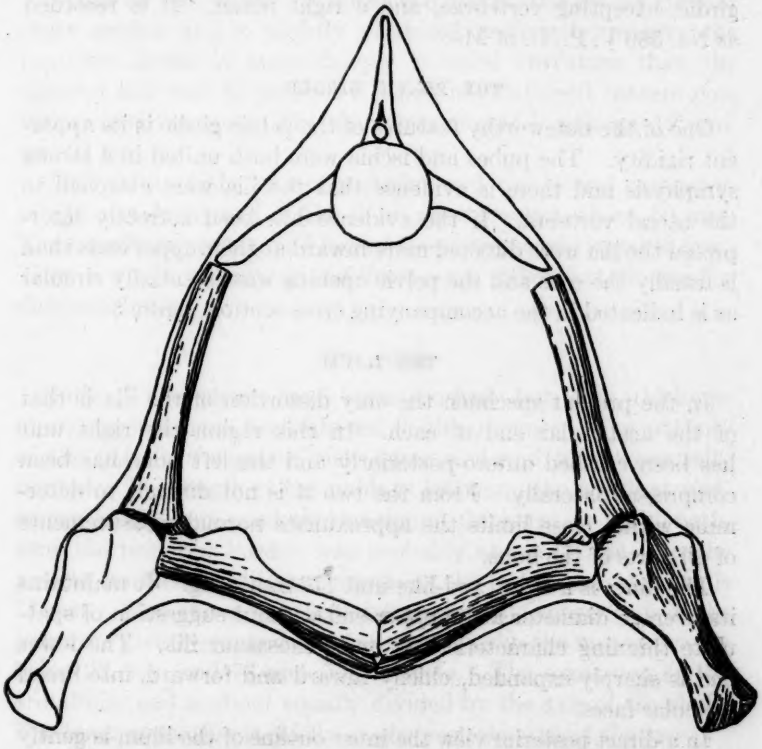


FIG. 5. DIAGRAMMATIC CROSS-SECTION OF *Platecarpus* (*Holosaurus*) *abruptus* MARSH, IMMEDIATELY BACK OF PELVIS, × ½

bones much less than seems to be the case with most of the specimens from the chalk beds. Some of the bones are almost entirely free from crushing and others that have not fared so well give evidence of the amount of distortion and, in consequence, indicate the normal proportions.

Platecarpus (Holosaurus) abruptus Marsh

The specimen described herewith was found by Mr. Aubrey Glines in the Niabrara chalk about 20 miles north of Scott City, Kansas. The material consists of an essentially complete pelvic girdle, excepting vertebrae, and a right femur. It is recorded as No. 586 V. P., U. of Mo.

THE PELVIC GIRDLE

One of the noteworthy features of the pelvic girdle is its apparent rigidity. The pubes and ischia were both united in a strong symphysis and there is evidence that the ilia were attached to the sacral vertebra. If the evidence has been correctly interpreted the ilia were directed more inward at their upper ends than is usually the case and the pelvic opening was essentially circular as is indicated in the accompanying cross-section, figure 5.

THE ILIUM

In the present specimen the only distortion of the ilia is that of the acetabular end of each. In this region the right unit has been crushed antero-posteriorly and the left bone has been compressed laterally. From the two it is not difficult to determine within close limits the approximate normal measurements of all parts of the bone.

The ilium is a stout, rod-like unit 172 mm. long. It maintains its average diameter at its upper end without suggestion of spatulate thinning characteristic of most mosasaur ilia. The lower end is sharply expanded, chiefly inward and forward, into broad articular faces.

In a direct posterior view the inner outline of the ilium is gently concave inward with a corresponding convex outer outline except at the lower end where the outline is concave for a short distance above the terminal expansion. In a direct lateral view the bone is somewhat sinuous, gently concave forward except at the upper end, a short length of which curves slightly back. The bone is directed up, a little forward, and very slightly inward from its acetabular attachment.

The upper end of the shaft is circular in cross-section with a

diameter of 20 mm. It terminates in a flat circular face of the same diameter, a plane at right angles to the shaft. It is this truncated terminis that evidences a firm though possibly cartilaginous attachment to a sacral rib.

About 30 mm. below its upper end the shaft loses its circular cross section and is slightly produced posteriorly to give the posterior border a more sharply rounded curvature than the anterior side and to produce a somewhat flattened (antero-posterior) inner surface. The diameters at mid-length are 19 mm. and 23 mm.

The width of the antero-posterior and the lateral expansion of the acetabular end of the ilium are subequal, about 50 mm. The acetabular, pubic, and ischial facets are nearly equal in area. They are not sharply set off from each other but are readily distinguishable.

THE PUBIS

Both of the pubes have been crushed, but only thickness measurements have been altered in this manner. The outlines of the pair in a superior view agree well and seem essentially normal. The length of the pubis is 190 mm., the width at mid-length is 130 mm., and the maximum thickness at mid-length, near the posterior border, was probably about 18 mm. In the present crushed condition of the bone the latter measurement is 13 mm. Both the symphyseal and the lateral (upper) ends of the pubis are greatly expanded antero-posteriorly, the measurements being 93 mm. and 73 mm. respectively. The expansion of the acetabular end is about equally divided by the axis of the shaft. The lower expansion is chiefly on the posterior side of the axis.

The ischial facet seems to have been very small, the articular surface of the outer end of the pubis being about equally divided between iliac articulation and acetabular surface. These two areas are not distinctly set off from each other and together form an articular surface about 73 mm. long (antero-posteriorly) and 45 mm. high. The latter measurement is of the specimen restored according to the evidence for the amount of crushing of this thickened end.

The pubic foramen pierces the shaft about 40 mm. from the acetabular end in a conspicuously posterior direction. The pubic process is a thin, triangular, concave (upward) plate about 60 mm. long at its base. It ends in a point 43 mm. in front of the foramen. The outer end of the base of the triangle is confluent with the outer end of the shaft.

THE ISCHIUM

The ischia of the present specimen have been crushed so as to appreciably thin the normally thick outer end. Other than this the outlines seem to be entirely normal and even for the crushed part a reasonable restoration is fairly simple. At any rate, measurements of the ischium including the restored part are as nearly correct as those of the crushed specimen.

The length of the ischium is 140 mm., considerably less than that of the pubis. It is evident that the posterior margin of the pelvis was somewhat constricted laterally and the floor tilted upward. At mid-length, near the anterior border of the ischium, the thickness of this bone is about 23 mm. From here it decreases to a comparatively thin plate at its symphyseal margin and thickens rapidly in the opposite direction to the expanded acetabular surface. The lower end is expanded to an antero-posterior width of nearly 80 mm. and unites with its mate along this entire width. The antero-posterior measurement at about mid-length is 40 mm.

The posterior margin of the bone is thin throughout its entire length and, near the outer end of the bone, is produced into a conspicuous tongue-shaped extension about 25 mm. beyond the posterior margin proper.

The articular surface of the outer end of the bone is in general convex. This surface is about 40 mm. high and 50 mm. antero-posteriorly, and is directed out, a little forward, and slightly up. Its division into acetabular, pubic, and iliac surfaces is not clear. The total width of the outer end of the bone is 80 mm., including the posterior tongue-like extension.

THE FEMUR

The femur is dorso-ventrally thinned by post-burial pressure, most conspicuously at the proximal end. The surface of the

crushed parts has been offset from the surface of undistorted parts in such a way as to make evident the essentially normal measurements of all parts of the bone. The proportions seen in a superior view have not been changed by the distortion. Other measurements include what the writer considers a logical restoration.

The length of the femur is 140 mm. The width of the proximal end is 72 mm., the mid-length width 42 mm., and the distal width 92 mm. The thickness of the shaft at mid-length is about 35 mm. The articular face of the head is markedly convex and is oval in outline, about 70 mm. antero-posteriorly and 40 mm. high.

The trochanter, rising from the tibial side, is a robust process extending, at its upper end, abruptly upward from the shaft a short distance below the femur head. The lower end of the process merges gradually with the shaft a little above mid-length of the bone.

The distal expansion is but little thickened. The tibial facet is a convex surface about 70 mm. wide and 40 mm. high. It is distinguishable from the fibular facet but is not sharply set off from it. The fibular articulation occupies the thin proximal-posterior corner of the femur and is about 35 mm. long, and 15 mm. high.

The articular surfaces of the femur are irregularly pitted for cartilage terminations probably of more than average thickness.

RELATIONSHIPS

There is no question concerning the broader relationships of the form here described although the synonymy involved is doubtful. The pelvis undoubtedly belongs to the group typified by *Platecarpus* and the writer refers it to that genus without hesitancy except for the doubtful status of the name as has been pointed out by Williston.[2]

The present specimen seems closest to the form admirably figured but somewhat briefly described by Capps[3] as *Holosaurus*

[2] S. W. Williston, Mosasaurs. Univ. Kans. Geol. Surv., 4 (pt. 1), 178-179 and 192-194 (1898).

[3] S. R. Capps, Jr., The girdles and hind limb of *Holosaurus abruptus* Marsh, Jour. Geol., 15, 350-356 (1907).

abruptus Marsh and later designated by Williston[4] as "*Platecarpus* (*Holosaurus*) *abruptus* Marsh." So marked are the similarities of the two specimens in all but the minor details that they should probably be considered the same species. The most striking differences consist of the less sharply recurved outer-posterior corner of the pubis, its more expanded symphyseal end, and the more anterior position of the foramen in the specimen here described. The ischium of this specimen is much less antero-posteriorly expanded at its inner end and is entirely lacking in a posterior extension along the symphysis.

Not all of these differences can be accounted for by various degrees of post-burial deformation although this has undoubtedly been an important factor. It does not seem unreasonable to assume that the differences that are considered normal are such as are to be expected among individuals of a species belonging to a group that has been modified rapidly toward perfect aquatic adaptation. Under the circumstances the writer feels justified in designating the present specimen as *Platecarpus* (*Holosaurus*) *abruptus* Marsh.

[4] S. W. Williston, A mounted skeleton of *Platecarpus*. Jour. Geol., 18, 537–541 (1910).

PLATE LXIV

AN ANTERIOR PYGAL VERTEBRA OF *Amphekepubis johnsoni* MEHL, POSTERIOR AND SUPERIOR VIEWS, × ⅔

A
B

PLATE LXV

PELVIC GIRDLE BONES FROM LEFT SIDE OF *Amphekepubis johnsoni* MEHL, × ⅔

Fig. 1, pubis from outer-inferior side; figs. 2 and 3, outer and posterior views of ilium; figs. 4 and 5, anterior and superior views of ischium.

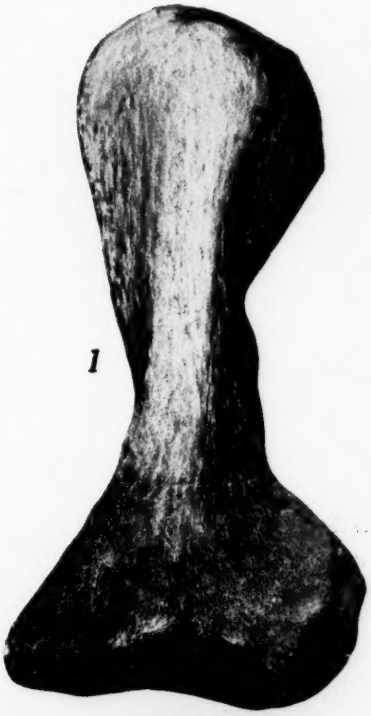
M. G. MEHL

NEW GENUS OF MOSASAURS

PLATE LXVI

BONES OF LEFT HIND PADDLE OF *Amphekepubis johnsoni* MEHL, ALL FIGURES × $\frac{2}{3}$

Fig. 1, superior view of femur; figs. 2 and 3, superior and inner side of tibia; fig. 4, superior view of first metatarsal.


1

4

2

3

PLATE LXVII

BONES OF LEFT HIND PADDLE OF *Amphekepubis johnsoni* MEHL, × $\frac{2}{3}$

Figs. 1 and 2, inferior and posterior views of femur; fig. 3, basal phalanx of first finger; fig. 4, fourth (?) metatarsal.

1
2
3
4
5

STREAM PIRACY NEAR ASHEVILLE, NORTH CAROLINA

FRANK J. WRIGHT

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INTRODUCTION

In the course of field studies during the season of 1927, the writer came across an interesting case of apparent drainage change involving tributaries of the French Broad and Pigeon Rivers in North Carolina. The French Broad flows northward by Asheville while the Pigeon has its basin to the southwest. Hominy Creek, the pirate stream, rises near Canton, and flows fifteen miles northeastward to join the French Broad several miles south of Asheville. The Pigeon River, which has lost tributaries to Hominy Creek, flows northeastward through Canton, and turns toward the west just beyond the village. The area is located in the southern part of the Asheville, North Carolina quadrangle.

The Asheville "amphitheatre" or local peneplane, first described by Willis,[1] was developed by the French Broad River in the last important geographical cycle, while the present valley of this stream, entrenched some 200 feet in its former peneplane, has been cut in the present cycle.[2] The Asheville peneplane today stands approximately 2200 feet above the sea at Asheville and rises up the main and tributary valleys.

Hominy Creek has developed its valley 100 to 150 feet below the Asheville surface which rises to an elevation of around 2350 feet at the Buncombe-Haywood County line, beyond which the former erosion level of the French Broad basin does not exist.

[1] Willis, Bailey. Round about Asheville. Natl. Geog. Mag., 1, 291–300 (1889).

[2] Wright, Frank J. The Erosional History of the Blue Ridge. Jour. Sci. Lab. Denison Univ., 23, 321–344 (1928).

From this point to its source the stream gradient increases and the valley becomes a gorge.

The village of Canton is located in the drainage basin of the Pigeon River, which likewise developed a broad mature valley in the last erosion cycle. The elevation of this level is approximately 2750 feet, and the Pigeon River flows about 150 feet below it. Thus, after the uplift which introduced the present cycle, these adjacent river lowlands differed in elevation approximately 400 feet. The Pigeon River flowed southwest while Hominy Creek flowed toward the northeast.

The most instructive viewpoints for the study of this drainage problem are on the remnants of the former Pigeon River level in and around Canton. From one of these remnants in the eastern part of Canton, and from another a mile to the north, the writer could trace the former extension of this surface up the North and South Forks and along the mountain slopes on both sides of the Hominy Creek gorge, as well as along the valleys of the Pigeon River and its tributaries above and below Canton. It is obvious that the drainage area of all these streams once belonged to the Pigeon River, for its former level is easily traced throughout. North and South Forks have notably dissected this former level near their junctions with Hominy Creek. The present valley of Hominy Creek, therefore, shows unmistakable evidence of two erosion levels, the Pigeon River level at 2750 feet and above, in the first four miles of its course, and the Asheville or French Broad level at 2350 feet and less, in its lower course.

EVIDENCE OF CAPTURE

1. Barbed tributaries. The most obvious evidence of drainage change is seen in the barbed arrangement of the two main headwater tributaries of Hominy Creek, North and South Forks (fig. 1). These tributaries, furthermore, are much larger than the trunk stream into which they flow. North Fork, for instance, is about five times as long as the stem which it joins, and its volume is proportionately perhaps even greater. These streams have a perfectly normal relationship to Pigeon River in both position and size.

By referring to the map (fig. 1), it will be seen that the tributaries which enter Hominy Creek east of the county line have quite normal relationships to the master stream. They form a normal dendritic pattern. To the west of the county line, however, the short tributaries enter at right angles or even have a mildly barbed relationship. The heads of two of these on the north side have southwesterly courses, which bend slightly to the south where they flow down the steep valley wall of the present-cycle gorge of Hominy Creek, the change in direction occurring at the level of the former Pigeon River erosion surface. Furthermore, it would seem that a short stream formerly rose

FIG. 1. MAP SHOWING THE DRAINAGE LINES OF THE ASHEVILLE-CANTON AREA, TAKEN FROM THE ASHEVILLE, N. C.-TENN. TOPOGRAPHIC MAP OF THE U. S. GEOLOGICAL SURVEY

at the county line about a half mile south of Hominy Creek and flowed toward the west. The drainage of this valley is now carried by several short northward flowing tributaries which were developed during the cutting of the gorge. This is apparently a barbed valley.

2. Remnants of the former Pigeon River level. There are abundant remnants of the former Pigeon River level in the valleys of North and South Forks and along the slopes of the mountains above the sides of the Hominy Creek gorge. The heads of North and South Forks have destroyed but little of this surface. On the north side of the Hominy Creek valley there is a broad bench at 2800 feet, while very near the County line on the

south side there is a splendid trace at 2900 feet. The surface appears at the same elevation also in both North and South Fork valleys and descends towards the present Pigeon River valley.

3. The gorges of Hominy Creek and North and South Fork. The eastward facing slopes at Canton are steep, while those to the west are gentle (fig. 2). The area around the junctions of South Fork and North Fork with Hominy Creek is sharply dissected to a depth of 250 feet by young valleys (fig. 3). The gorge of Hominy Creek is cut to a depth of from 300 to 500 feet below the former valley floor of Pigeon River. These valleys, therefore, contrast sharply with those of Pigeon River and its tributaries which have been developed only 100 to 200 feet below their former levels, as seen in figure 2.

Furthermore, the gorges of North and South Forks open out upstream into wider and more mature valleys. The heads of the North and South Fork valleys are quite similar in stage of development to those in the Pigeon River system. These gorges are developed precisely where they should be on the basis of piracy.

The steep gradient of Hominy Creek near its source is well attested on the map and in the field. A tributary of North Fork which enters about one mile north of the junction of North Fork and Hominy Creek has a clearly developed hanging valley, its level being more than a hundred feet above North Fork. The latter stream itself has a number of rapids and local waterfalls several feet in height.

4. Stream gravels. In the eastern end of Canton, on the divide between Hominy Creek and Pigeon River, there are abundant well-rounded but pitted gravels. The rounding has been followed by weathering which has made the surfaces irregular. This characteristic has been observed by the writer in the gravels of many localities in the Southern Appalachians. They vary in size from small gravels up to boulders at least six or eight inches in diameter.

SUMMARY

1. On the basis of the evidence briefly stated, it appears that Hominy Creek has captured an unnamed tributary of Pigeon River as well as a number of tributaries of this stream, chief of which are North and South Forks. The former divide stood approximately at the present position of the Buncombe-Haywood County line. From a study of the map it is seen that the mountains on both sides converge at this point, indicating its former position. East of this divide the French Broad-Hominy Creek local peneplane was developed during the last cycle, while to the west Pigeon River carved a broad mature valley.

2. Age. It is more than probable that the diversion was effected in the early part of the present cycle, following an uplift which left the two contiguous drainage basins with a disparity in elevation amounting to 400 feet. The writer is not prepared to give the geological date of the formation of these two local erosion surfaces, but he is convinced that they were developed at the same time, during the last cycle of erosion, and are contemporaneous with the widely developed Appalachian Valley peneplane. No account is here taken of brief parts of cycles which have left their traces below the general valley level, in the so-called Tertiary areas of the Appalachian states. So far as the writer is aware, this is the first illustration of its type that has been described in the Older Appalachians of the South. Similar diversions associated with the Blue Ridge, however, will be described later.

3. Absence of elbow of capture. This little example of piracy shows most of the normal effects of drainage adjustment with the exception of the elbow of capture. The contest was head-on, and consequently the direction of flow of the main stream was simply reversed.

This deficiency, however, will soon be supplied, for Hominy Creek is still engaged in vigorous cutting at its head, and will in the near future, geographically speaking, tap the waters of Pigeon River at the village of Canton, and lead them away through a steep-walled gorge at the elbow of capture.

ACKNOWLEDGMENT

Grateful acknowledgment is hereby made to the New York Academy of Sciences for a grant from the Esther Hermann Research Fund which was used to help defray field expenses.

PLATE LXVIII

Fig. 2. Slightly dissected basin of Pigeon River looking upstream across the village of Canton, N. C. Accordant low hills on both sides of valley preserve the Pigeon River level at an elevation of approximately 2750 feet.

Fig. 3. Sharply dissected Pigeon River level at the junction of North and South Forks with Hominy Creek, about 1.5 miles east of Canton, N. C.

FIG. 2

FIG. 3

FRANK J. WRIGHT STREAM PIRACY NEAR ASHEVILLE, N. C.

MOTOR VEHICLE TRANSPORTATION COST AND ITS RELATION TO HIGHWAY FINANCE

BRUCE D. GREENSHIELDS

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The total registration of motor vehicles in the United States in round numbers is 25,000,000. This means that there is one automobile for every 5.6 persons and nearly 40 for every mile of improved road in the United States. The motor car industry ranks first in the United States. The highway bill is approximately $1,500,000,000 per year. This, however, amounts to only about one-half of the amount paid for gasoline and tires. Nearly everyone is more or less interested in the cost of motor car operation and in highway improvement.

The Iowa State Experiment Station has published a bulletin[1] by T. R. Agg and H. S. Carter giving a summary of the operating costs of various types of automobiles. These figures, which are widely quoted, are given in table 1.

It is our purpose in the present discussion to show the significance of the various items, some of which are fixed, while others depend upon the number of miles travelled. The items of gasoline, oil, tires, and tubes, and maintenance will vary more or less closely with the actual number of miles travelled. License, garage, interest, and insurance are fixed charges and will be constant whether the automobile is driven ten miles or ten thousand miles. Depreciation will undoubtedly vary with the number of miles travelled, but not exacty so, because the value of an automobile depends more upon what model it is than upon how many miles it has travelled. There is no way of telling just how depreciation varies with time and how it varies with usage. To be conservative in applying the costs to the economics of highway construction and for simplicity in figuring, we will consider all the

[1] Agg, T. R., and Carter, H. S. Bul. 91, Iowa State College.

depreciation among the fixed charges. The number of miles travelled each year has a very definite bearing upon the cost per mile, as is shown by the accompanying graph.

If the owner drives only a small number of miles each year it will evidently be cheaper for him to rent a car than to own one. Two thousand miles per year in a taxi sounds like an expensive proposition, yet as can be seen from the graph, it would be just as

TABLE 1

Average cost of automobile operation

Based on detailed cost records covering about 1200 automobiles operated in various parts of the United States and an average of 11,000 miles per year

ITEMS	TYPE OF CAR						
	Light 4 Average	Medium 4 Average	Heavy 4 Average	Light 6 Average	Medium 6 Average	Heavy 6 Average	Imaginary "Average" Automobile
	cents per mile	*cents per mile*	*cents per mile*	*cents per mile*	*cents per mile*	*cents per mile*	*cents per mile*
1. Gasoline at 20 cents per gallon.	1.34	1.14	1.31	1.36	1.52	1.42	1.31
2. Oil	.25	.17	.16	.18	.20	.17	.22
3. Tires and tubes	.60	.65	.70	.75	.80	.90	.64
4. Maintenance	1.55	1.90	2.06	1.95	2.14	2.53	1.72
5. Depreciation	1.25	1.40	1.57	1.74	2.09	2.57	1.39
6. License	.11	.14	.20	.20	.24	.27	.14
7. Garage at $4 per month	.44	.44	.44	.44	.44	.44	.44
8. Interest at 6 per cent	.27	.38	.55	.55	.71	.87	.36
9. Insurance (fire, theft, tornado, liability)	.21	.20	.21	.21	.26	.28	.21
Total	6.02	6.42	7.20	7.38	8.40	9.45	6.43
Annual mileage	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Average miles per gallon gas.	14.95	17.53	15.29	14.68	13.19	14.02	

cheap to hire a taxi as to use your own car if you were only driving that far each year. From the above chart we find, (by multiplying the fixed charges by 11,000), that to own a medium priced car costs $279.40 a year, if it is not driven at all. That is, it costs 76 cents a day to have a car at your disposal.

This idea may be shown by another illustration. We will say that a man driving a car 7,000 miles per year finds that it costs

him 10 cents per mile. If he decides to take a short trip today—say of fifteen miles—this fifteen miles will not cost him 10 cents

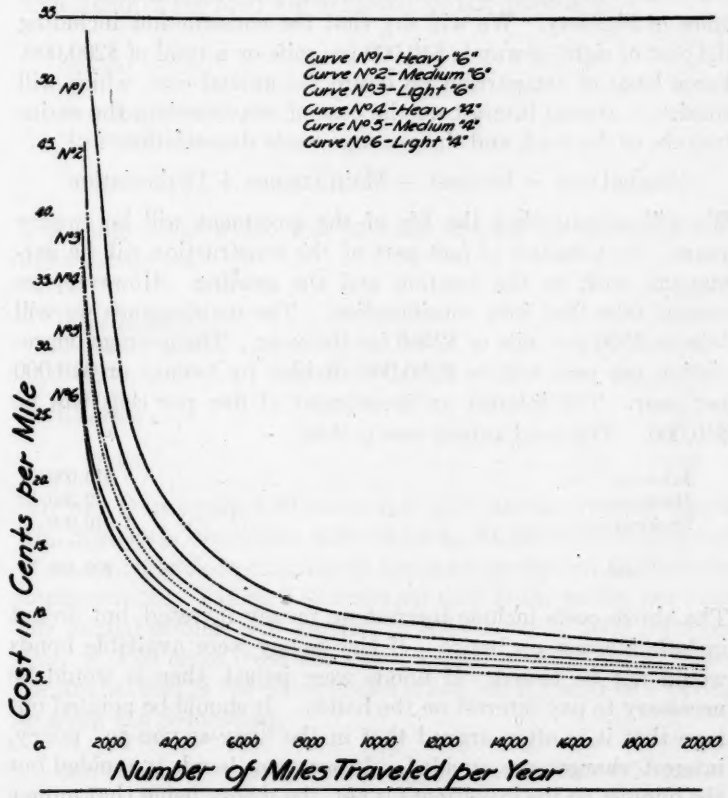

FIG. 1. OPERATING COSTS OF MOTOR VEHICLES
(Agg and Carter, Bul. 91, Iowa State College)

a mile, but only 4 cents, because whether he takes a trip or not he has paid the other 6 cents in fixed charges.

We will now apply the above tabulated cost to a problem in highway location. The distance from Granville to Columbus,

Ohio, is 27 miles. We will suppose that the average number of vehicles per day is 2,500 and that it is possible to shorten the route one mile by re-location involving the construction of five miles of highway. We will say that the construction including the cost of right-of-way is $40,000 per mile or a total of $200,000. For a basis of comparison we desire the annual cost, which will consist of annual interest on the cost of construction, the maintenance of the road, and the average yearly depreciation, *i.e.*,

Annual cost = Interest + Maintenance + Depreciation

We will assume that the life of the pavement will be twenty years. As a matter of fact part of the construction will be permanent, such as the location and the grading. However, we cannot take that into consideration. The maintenance we will take as $500 per mile or $2500 for the year. The average depreciation per year will be $200,000 divided by twenty or $10,000 per year. The interest on investment at five per cent will be $10,000. The total annual cost is then

Interest	$10,000
Maintenance	2,500
Depreciation	10,000
Total	$22,500

The above costs include interest on money invested, but do not include interest on bonds. If the money were available bonds would not be issued. If bonds were issued, then it would be necessary to pay interest on the bonds. It should be pointed out here that it is often argued that in the "pay-as-you-go" policy, interest charges are avoided. Interest on bonds is avoided but the interest on the investment is not, the theory being that money is worth so much, and has a certain earning power. If money is borrowed by issuing bonds, the interest on the bonds pays for the use of the money. If money on hand is spent its earning power is also lost. In one case interest is paid out, in the other interest is lost, so that in either case the result is the same. *The economic question of whether a highway should be improved now or later depends on whether the annual saving in transportation costs will more than equal the annual cost of the improvement.*

We will now figure the amount saved by the shortening of the road.

Of the above tabulated costs per mile, those saved by the shortening of the road will evidently be the following:

	cents
Gasoline	1.31
Oil	.22
Tires and tubes	.64
Maintenance	1.72
Total	3.89

The other items which will be little affected by the number of miles driven are:

	cents
Depreciation	1.39
License	.14
Garage	.44
Interest	.36
Insurance	.21
Total	2.54

We will then apply 3.89 cents per mile, as the amount saved. The mistake is sometimes made of using the entire operating cost of an automobile in calculating the savings effected by highway improvement. Taking 3.89 cents per mile as the saving per mile, our annual savings will amount to 365 (days) $\times$ 2500 (cars per day) $\times$ 3.89 cents (cost per mile), a total of $35,496.25. Since the annual cost of the construction is $22,500 it would be a saving to make the re-location.

THE PROBLEM OF A TRAFFIC LIGHT ON A BUSY CITY CORNER

Assume traffic moving at 15 miles per hour, and a double lane of traffic on each side. There would be a car at least every 50 feet. With traffic this heavy one-half of the traffic would be stopped at all times, as the traffic on the cross street would be passing for one-half the time. The solution for several intersections in succession would be the same and perhaps would be the usual problem.

15 miles per hour = 22 ft. per second.

$\frac{50}{22}$ = 2.27 seconds for a car to pass.

In a 16 hour day there are 57,600 seconds.

$\frac{57,600}{22.7}$ = 25,300 cars per day. These are stopped one-half of the time. Suppose that each is idling at the rate of two miles per hour. The car miles these idling cars run per day = 25,300 (cars) × 2 (miles per hour) × 8 (hours) = 404,800 car miles per day.

Annual Expense = 404,800 (car miles) × 365 (days) × 3.89 (cents) = $5,750,347 per year.

The above methods of computing the annual cost and of applying the cost of motor car operation to highway finance may not be the usual ones, but it is believed that they are in accordance with good economic principles and are simple.

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NOTE: In accordance with a ruling of the postal authorities it has become necessary to change the name of this publication from "BULLETIN" to "JOURNAL" of the SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.